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SURGERY

A Monthly Journal Devoted to the Art and Science of Surgery

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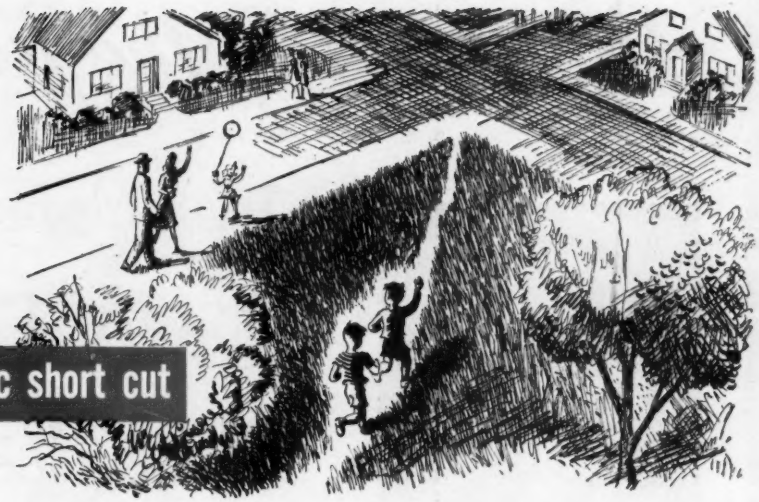

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1. Editorial: J. A. M. A. 121:346, 1943
2. Nadal, J. W.: Northwest Med. 46:444, 1947
3. Sprinz, H.: M. Clin. North America 30: 363, 1946
4. Brunschwig, A., Clark, D. E., and Corbin, N.: Mil. Surgeon 92:413, 1943

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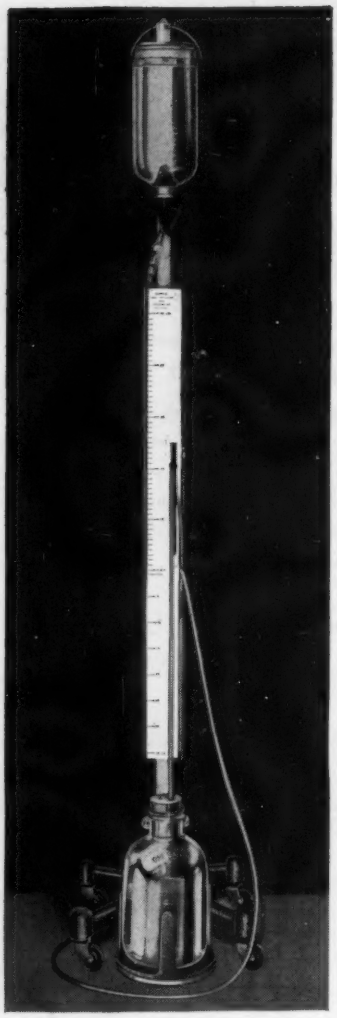

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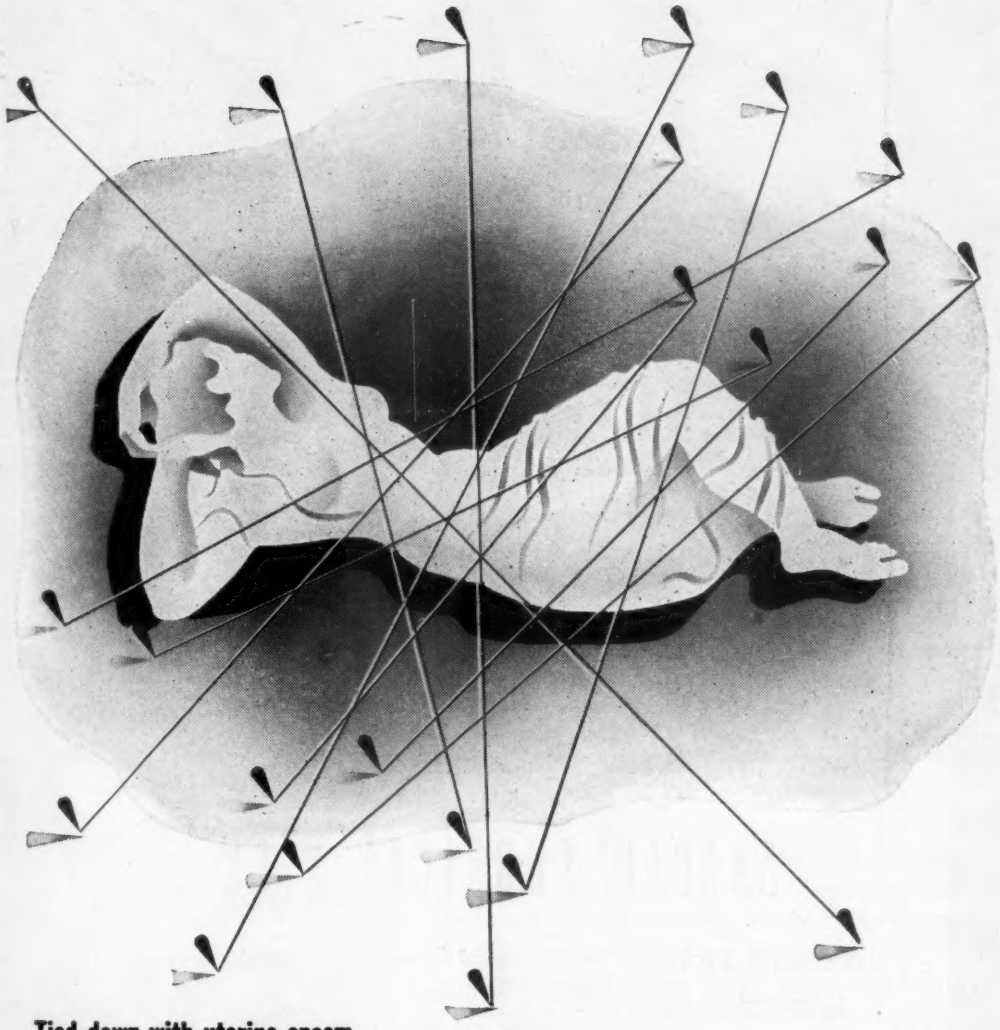

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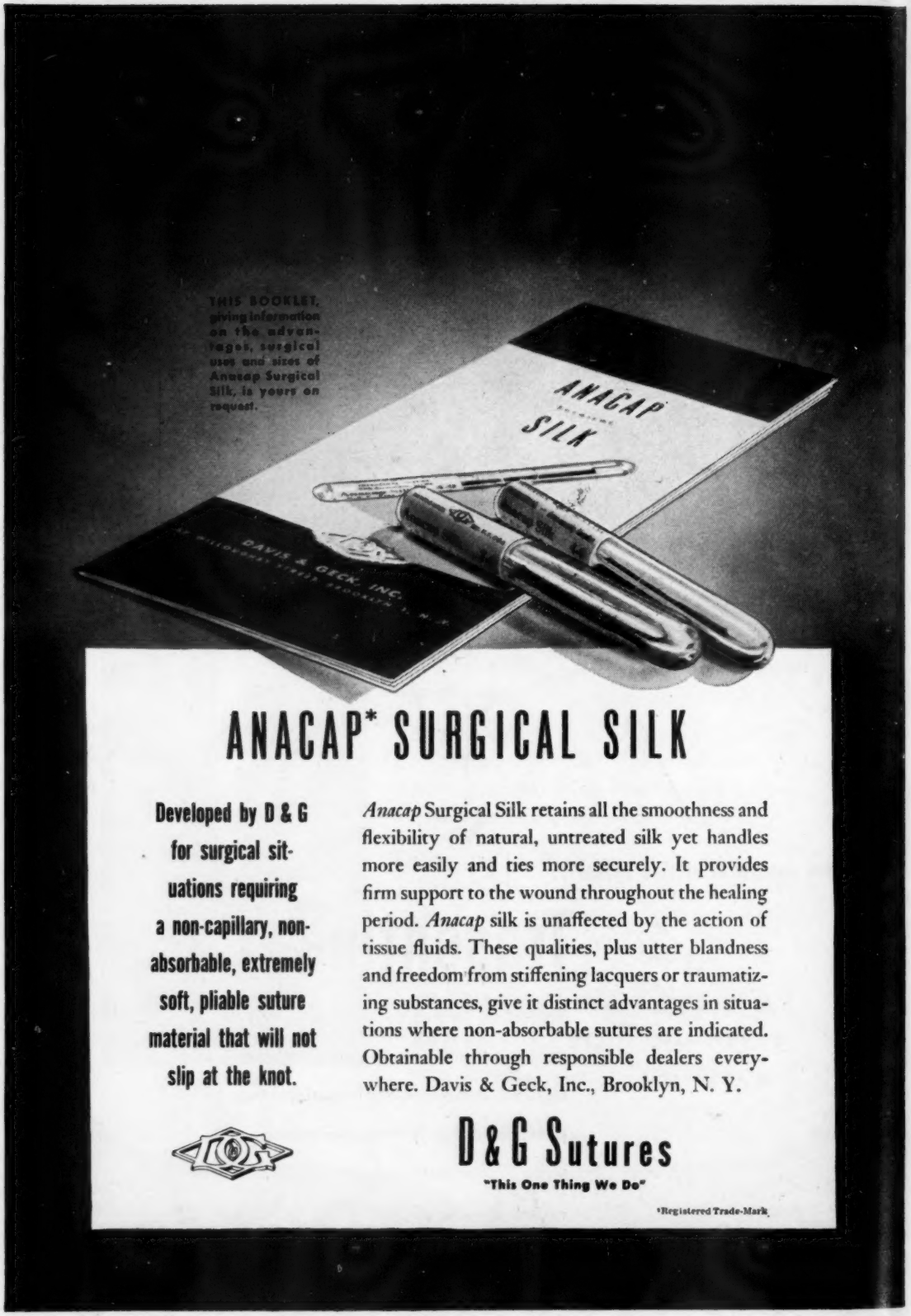
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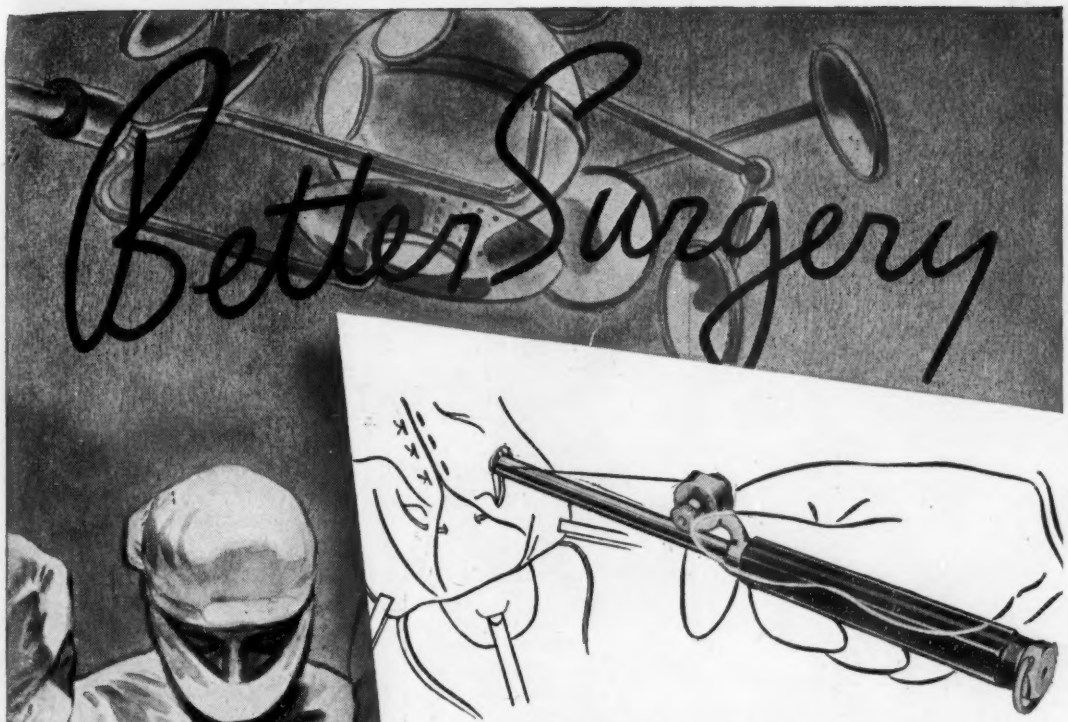

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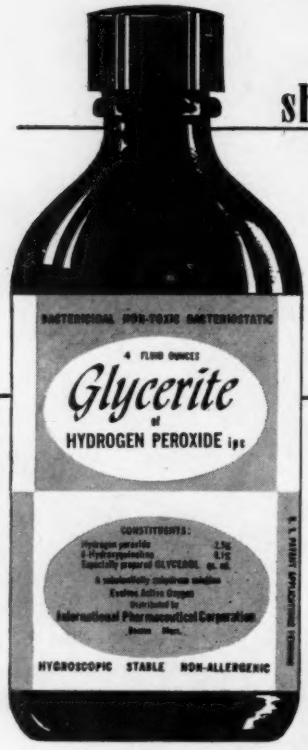

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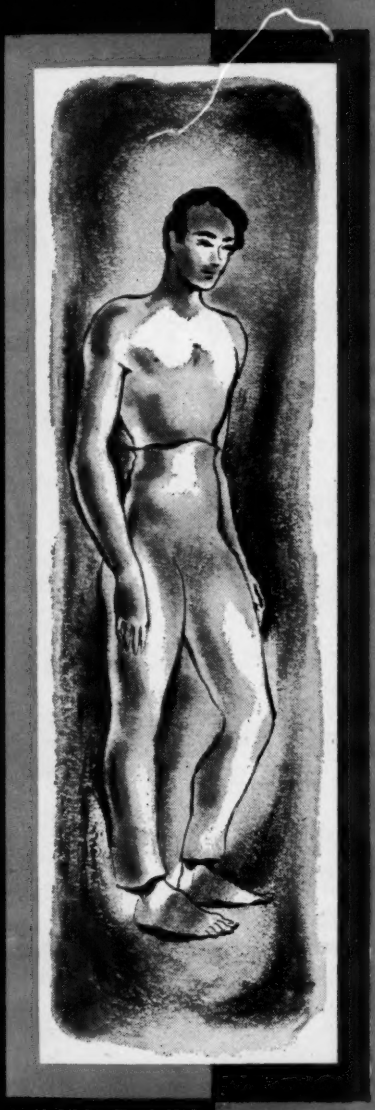

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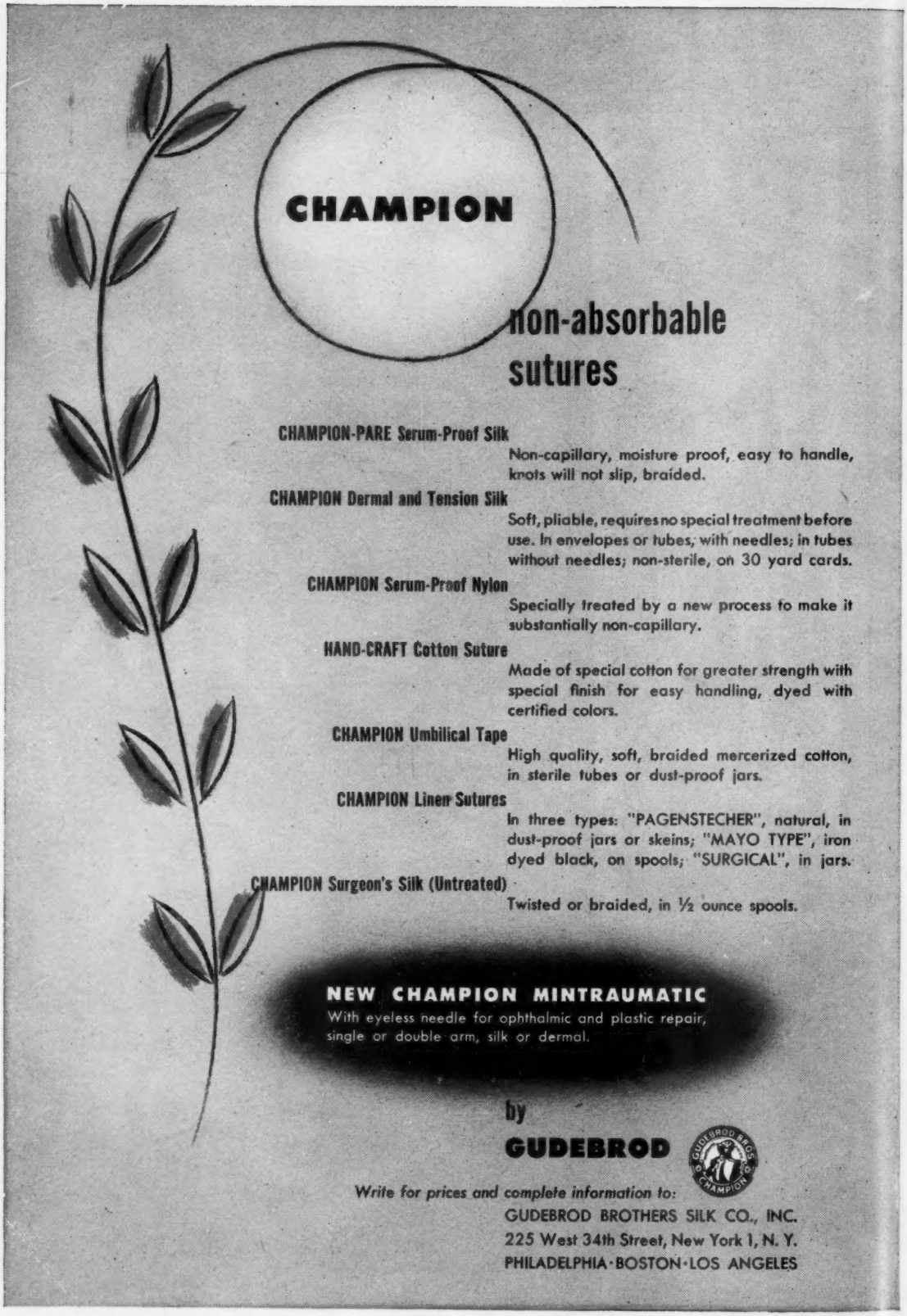
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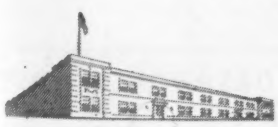

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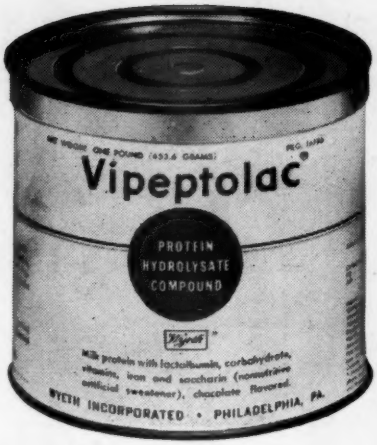

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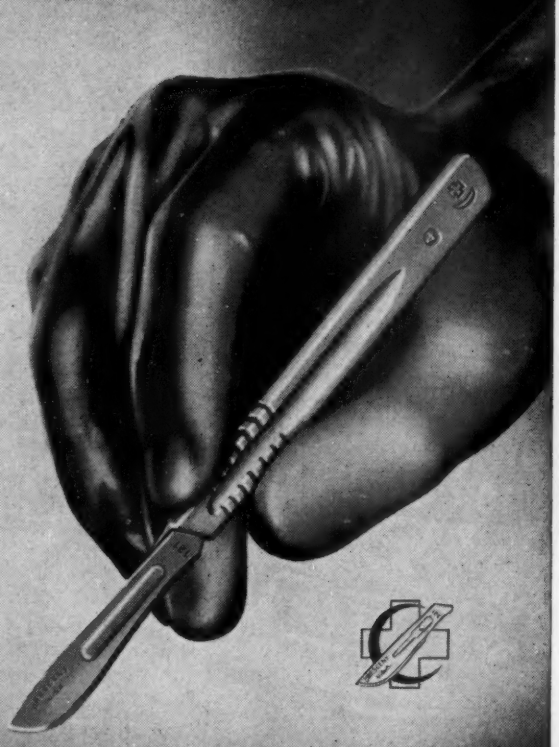

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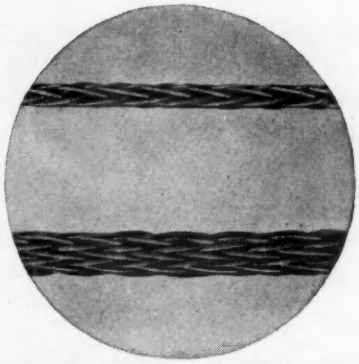

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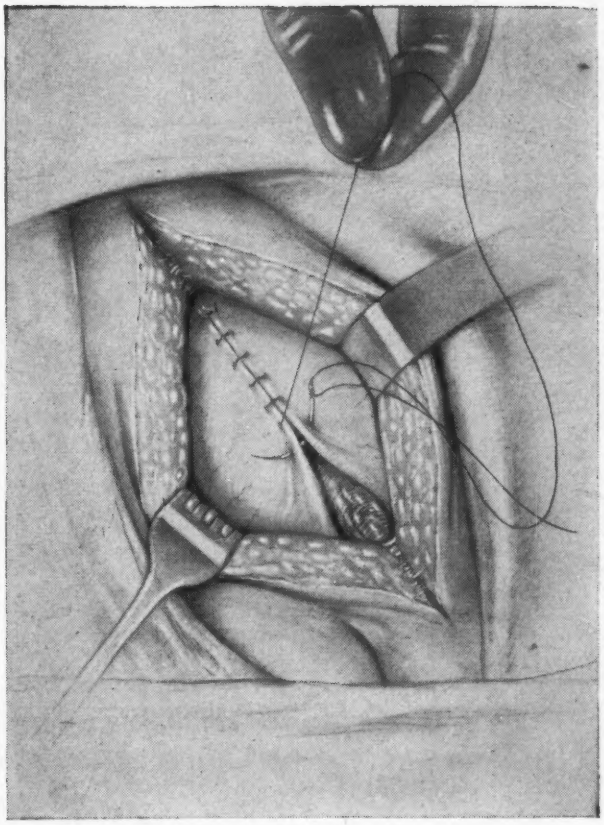

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SURGICAL CURE OF INNOMINATE ANEURYSM

REPORT OF A CASE WITH COMMENTS ON THE APPLICABILITY OF SURGICAL MEASURES

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ANEURYSMS of the innominate artery present a difficult problem in therapy and there are few reported instances of surgical cure. Excluding such auxilliary measures as wiring, distal arterial ligation, and the production of a distal arteriovenous fistula, thirty-seven attempts at direct operative attack have been recorded. Only nineteen of the patients so treated have survived the procedure and not all of them have been cured. It seems desirable, therefore, to report another successfully treated patient and to inquire into the applicability of surgery in such lesions.

CASE REPORT

The patient was a 25-year-old soldier who had been struck in the suprasternal area by a small shell fragment on July 14, 1944. There was no external bleeding. Two thoracenteses were required because of right hemothorax. For a while he progressed satisfactorily but nine days after injury when he was told he was being returned to duty he became very hoarse; for some days he was unable to speak at all. He was transferred to several replacement centers and hospitals, including a psychiatric installation, until finally, in November, it was discovered that he had a right recurrent laryngeal paralysis and a mass in the anterior mediastinum. Up to this point it had been thought that his complaints were on a functional basis. He arrived in the Zone of the Interior on December 10 and at the Mayo General Hospital on December 22.

The patient had regained normal voice. He complained of a constant sense of oppression which was accentuated by forward bending and which was felt in the upper anterior part of the chest. He breathed normally without discomfort but experienced substernal pain on deep inspiration. There was some difficulty in swallowing dry foods. He attributed his thirty pounds loss of weight to poor appetite. He complained of some weakness of the right upper extremity and noted that it was often darker in color than the left and that the veins of the right hand appeared distended as compared with those of the other hand.

Examination revealed a tall, thin, somewhat apprehensive young man who was in no distress. The general examination was not remarkable. No mediastinal mass was evident on percussion. In the right supraclavicular fossa and to a lesser extent in the suprasternal notch and over the upper sternum and to the right of it, a loud systolic bruit was audible.

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Pulses in the upper extremities were about equal in forcefulness. Blood pressure was 134/80 in the right arm, 146/90 in the left. The veins of the right hand were somewhat distended. No color changes in the extremities were noted and sweating was normal. In a room at 22° C. the fingers of the right hand were from 2° to 5° C. cooler than those of the left.

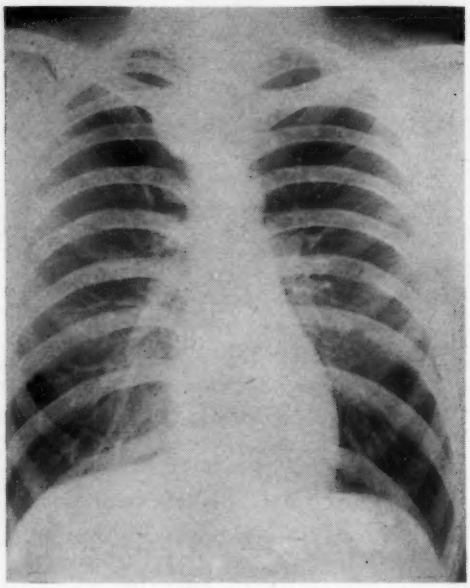

Fig. 1.

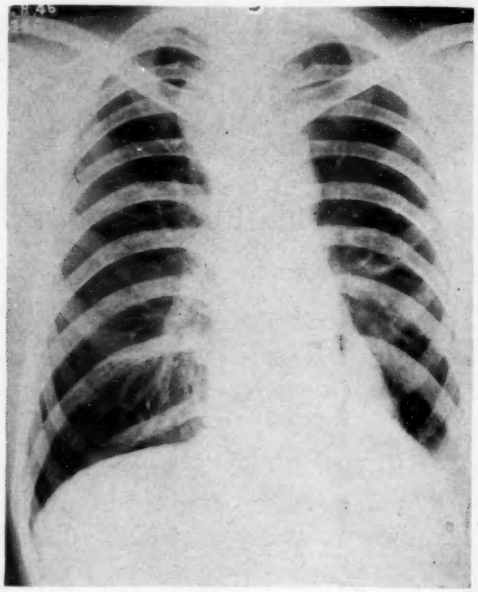

Fig. 2.

Fig. 1.—Roentgenogram taken shortly after admission. A shadow compatible with that of an innominate aneurysm is seen.

Fig. 2.—Roentgenograms taken eight days after the first operation; the mass is no smaller.

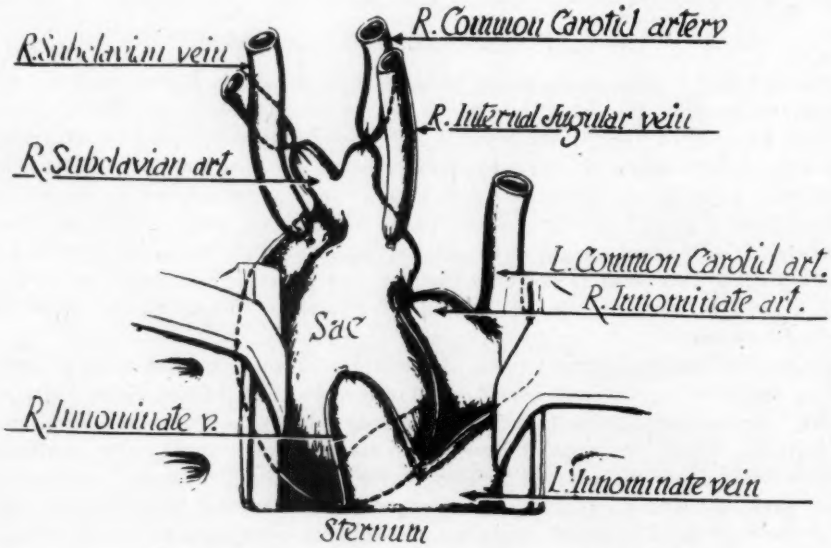

Fig. 3.—Semidiagrammatic drawing of the aneurysm.

Oscillations were equal in the two arms on oscillometry, slightly less at the right wrist than at the left. Ergometry revealed some weakness of the right hand. Laryngoscopic examination showed paralysis of the right vocal cord. Electrocardiograms were normal. Roentgenograms demonstrated a mass in the upper right section of the anterior mediastinum (Fig. 1).

The impression was held that the patient had a traumatic innominate arterial aneurysm and a right recurrent laryngeal palsy. He withstood prolonged right carotid compression repeatedly without difficulty.

On Feb. 15, 1945, under intratracheal anesthesia, exploration was carried out through a sternal-splitting incision. The sternum was divided down to the level of the third interspace and across into the interspace on both sides. A large saccular aneurysm of the

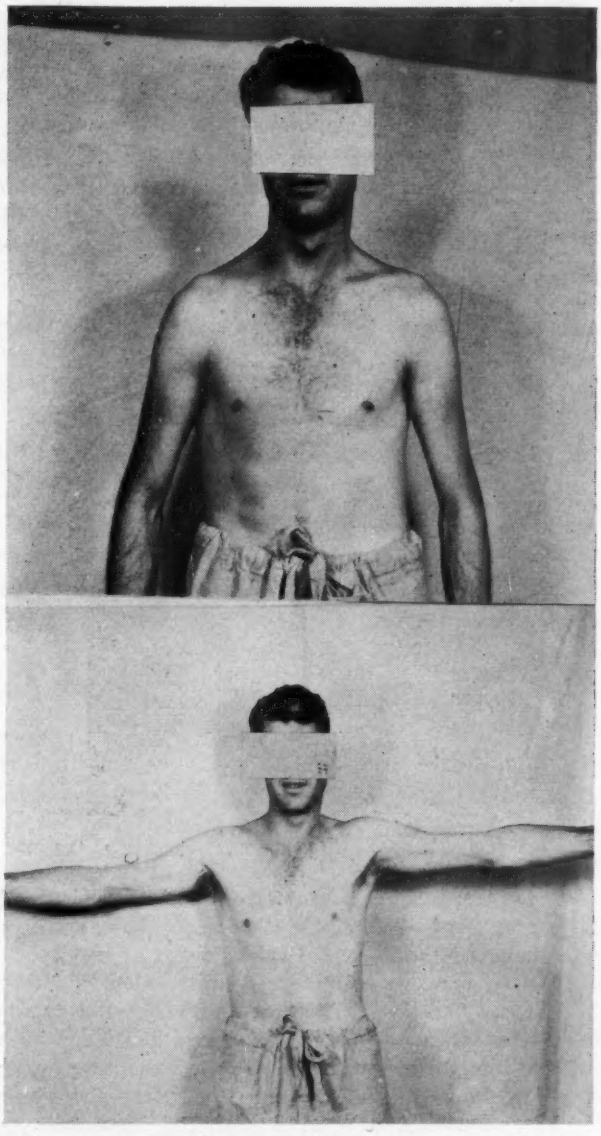

Fig. 4.—Postoperative photographs of the patient. The contour of the chest is normal and shoulder movements are not restricted.

innominate artery was found, involving a considerable length of this vessel and beginning about 2 cm. distal to its origin. The artery was occluded proximally with a rubber-shod clamp. The right hand immediately became extremely pale and cold, and neither color nor warmth returned during the fifteen-minute period of occlusion. Because of this observation it was felt unwise to carry out complete ligation. Consequently, the artery was con-

stricted to about one-half of its diameter with a strip of fascia which was secured with interrupted mattress sutures of silk, and by a band of cellophane about the artery. After the partial ligation the right radial pulse was smaller than the left and oscillometric studies revealed that oscillations in the right arm were reduced by about 40 per cent as compared with those in the left arm.

During the next few days the pulses and oscillations in the right upper extremitiy were reduced, but by the fifteenth day they were equal to those in the left. The bruit had increased in intensity after operation but was now the same as on admission. Roentgenograms revealed the aneurysm to be no smaller (Fig. 2). It was felt that the band about the artery had possibly given way; at any rate there was no longer evidence that the artery was partially constricted. In view of the ischemia which had occurred during complete temporary occlusion, it was decided to perform a sympathectomy in the hope that it might render the collateral circulation adequate. This was carried out on April 9. Thereafter, the right hand was warmer and better colored than the left.

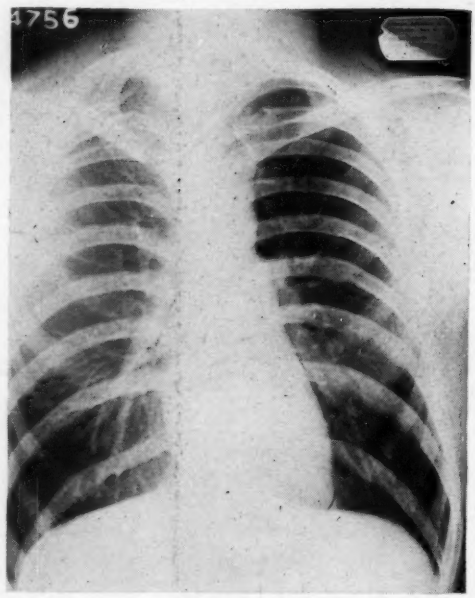

Fig. 5.—Roentgenograms taken eleven weeks after the final operation; the mass has disappeared.

On June 2 the mediastinum was again explored. At the initial operation the proximal artery had been readily accessible but not the subclavian which lay underneath the retracted right side of the manubrium and the sternoclavicular joint. Consequently, in order to provide better exposure, splitting of the sternum was supplemented by subperiosteal resection of the inner third of the right clavicle. The anterior scalene muscle was sectioned. Exposure was excellent. The aneurysm was about 10 cm. long and 6 cm. in diameter (Fig. 3). It lay in the right side of the mediastinum and extended one centimeter above the upper border of the divided manubrium. It was lateral to the artery and was partly covered by the innominate vein. The subclavian, internal jugular and innominate veins were divided between transfixing ligatures and the intervening segment removed. There was a great deal of scarring in the vicinity of the previous partial ligation and this made isolation of the proximal artery difficult. As this was being accomplished the sac was torn just at its origin. Bleeding was effectively controlled by digital pressure while a clamp was placed across the innominate artery and the carotid and subclavian arteries were divided between transfixing ligatures of silk. The proximal innominate artery was now ligated with umbilical tape and transfixed and ligated with silk just distal to the tape. The aneurysm was completely stilled and there was no bleeding. The sac was opened widely and a large

amount of laminated thrombus removed. A little fibrin foam was placed in the wound. The sternum was brought together with three wire sutures; the clavicular periosteal bed was closed with silk sutures, as were the fascia and skin. Blood pressure had not fallen below 130 mm. during the operation; two pints of whole blood had been administered.

Two hours after operation a nonpulsatile hematoma developed in the wound. The skin sutures were removed, the clot evacuated, and since no bleeding occurred after thorough irrigation, the wound was closed. There was no further bleeding.

The postoperative course was uneventful. The patient was kept in bed for approximately three weeks. There was good firmness in the region from which the clavicle had been resected, normal contour, and normal movements of the shoulder (Fig. 4). There was no bruit and there were no complaints except for persistence of the slight weakness of the right upper extremity. The right hand remained warm and well colored. After a long furlough he was separated from the service early in September, 1945. He still had a vocal cord paralysis but spoke well. Roentgenograms showed no mass in the area formerly occupied by the aneurysm (Fig. 5). The patient has remained well except for slight general weakness and a little fatigability of the right hand.

DISCUSSION

In Table I are listed data concerning thirty-eight reported cases of attempted surgical treatment for innominate aneurysm. References to all but the last two are included in the reports of Greenough,[1] Rundle,[2] and Lindskog.[3] I have omitted one patient listed by Greenough in whom the ligation of the artery was apparently distal to the aneurysm (Cuneo) and I have included three cases (Cooper, Gay, Ballance) cited by Greenough as subclavian aneurysms, which, according to the operators' description, apparently involved the distal portion of the innominate. Patients treated by wiring of the aneurysm, distal ligation, and surgical production of an arteriovenous fistula are not included.

It is apparent that the mortality in the reported cases is very high in the patients treated some time ago and much lower in those operated upon in recent years. Excluding those cases of Matas in which the date of operation is not given, twenty operations were performed prior to 1924 with deaths in thirteen, a mortality of 65 per cent, while fifteen were done more recently with four deaths, a mortality of 20.7 per cent. Whether the mortality rate has actually been improved to this extent is open to question. It is likely that nearly all of the earlier cases may have been reported, while in recent years there has perhaps been a tendency to continue to record in the literature most of the successful cases but not all of those in which a fatal outcome prevailed. Nevertheless, it would appear that the mortality rate has been significantly reduced. This achievement can be attributed only in part to the fact that aseptic technique has become well established, anesthesia safer, and operations made less hazardous by the use of blood transfusions. As one can easily ascertain from reading the various reports, some of the early cases were lost because of inadequate operative exposure. Elsewhere this subject is being presented[4] and will not be discussed further here. Needless to say, adequate exposure is essential.

It appears that the age of the patient has not been an important factor in the mortality rate. Considering those cases in which such data are available, the average age of the patients who died in the early group was 45 years, of

TABLE I. REPORTED CASES OF DIRECT SURGICAL ATTACK UPON INNOMINATE ANEURYSMS

CASE NO.	SURGEON	YR. OF OPERATION	ANEURYSM		AGE OF PT.	SURGICAL PROCEDURE*	RESULT
			TYPE	LOCATION			
1	Key	1844	Spontaneous	Distal I & S	46	Attempted ligation	Died 23rd day of tracheal obstruction
2	Cooper	1859	Spontaneous	B	–	Ligation I	Died of uremia
3	Helferich	1890	Spontaneous	B	39	Attempted ligation, sac torn, packed	Died 16th day of infection
4	Parham	1894	Spontaneous	B	48	Attempted ligation through sternal trephine	Died in 17 hours
5	Burrell	1895	Spontaneous	B	54	Ligation I	Recovery and relief; died 104 days later of arteriosclerotic heart disease
6	Gray	1896	Spontaneous	–	39	Ligation I, ligation C, 19 days later	Died 42nd days of hemorrhage and infection
7	Gay	1896	Spontaneous	B	39	Ligation I, ligation C, 32 days later	Died of secondary hemorrhage and infection on 41st day
8	Bennett	1898	Spontaneous	B	55	Ligation and division I	Died 3rd day of hemorrhage
9	Schumpert	1898	Spontaneous	B	42	Ligation I	Died 5th day of cerebral softening
10	De Laup	1900	Spontaneous	B & S	58	Ligation I	Died 18th day of secondary hemorrhage while vertebral and carotid arteries were being ligated; original ligature had cut through and circulation had been reestablished
11	Ballance	1902	Spontaneous	B	35	Ligation I & C	Died 2nd day with hemiplegia
12	Halsted	1907	Spontaneous	B	51	Ligation I	Recovery. On 18th day metal band placed about carotid. Unimproved until shortly before death 11 mo. later
13	Kimura	1908	Spontaneous	B	46	Ligation & div. I, C, & S; Partial excision of sac	Cure; follow-up 17 mo.
14	Ballance	1909	Spontaneous	B	35	Sac was torn, ligation I	Died in 30 hr.
15	Sargent	1909	Spontaneous	Mid. & distal I.	67	Ligation I & C	Recovery, relief, died 17 mo. later of pneumonia and nephritis
16	Lessnoi	1915	Traumatic	Distal I. & C.	–	Ligation I	Cure
17	Hamann	1916	Spontaneous	B	59	Ligation I & C	Died 4th day with hemiplegia
18	Reid	1918	Spontaneous	I involving origin	45	Died before ligation accomplished	Carotid and subclavian ligation had been performed 10 mo. previously
19	Halstead	1918	Traumatic	Distal I.		Rent in artery sutured after opening sac	Recovered, good result

*Abbreviations: I, innominate; S, subclavian; C, carotid; B, bifurcation of innominate.

TABLE I—CONT'D

CASE NO.	SURGEON	YR. OF OPERATION	ANEURYSM TYPE	ANEURYSM LOCATION	AGE OF PT.	SURGICAL PROCEDURE*	RESULT
20	Ballance	1918	Spontaneous	Distal I	60	Ligation	Cure, died 2½ yr. later of pulmonary infarct
21	Matas	----	Spontaneous	I	–	Metal band about I	Died on 6th day, hemorrhage and pulmonary complication
22	Matas	----	Spontaneous	I	–	Metal band about I	Recovered
23	Matas	----	Spontaneous	I	–	Metal band about I	Recovered
24	Greenough	1924	Spontaneous	Distal I	45	Ligation I, C & S	Recovery, relief, follow-up 5 mo.
25	Miller, Dolby, Ballance	1925	Spontaneous	Distal, I & B	54	Ligation I; subsequent ligation C & S	Recurred 8 yr. later with death from rupture
26	Flint	1927	Traumatic	B	37	Ligation I, transaccular ligation S, packing	Cure, six mo. follow-up
27	Soutar	1933	Spontaneous	Distal, I & S	62	Ligation I & S	Well
28	Lexer	1934	Traumatic, arterio-venous	I	24	Transvenous suture I, ligation I vein	Died 17th day of infection
29	Turner	1934	Spontaneous	I	67	Attempted ligation	Died of hemorrhage on 4th day; carotid and subclavian had been ligated some years preceding operation
30	Edwards, Carling	1935 1936	Spontaneous recurrent	I I	64 –	Ligation I Ligation I, C & S; sac excised	Recurred Cure, follow-up 1 yr.
31	Carling	1936	Spontaneous	I	49	Ligation I, C & S	Paresis, living 2 yr. later
32	Meade	1936	Spontaneous	Distal, I & S	65	Ligation I & S with fascial strips	Improved, pulsation persisted
33	Brock	1939	Spontaneous	I, and another of aorta	66	Ligation I	Infection and hemorrhage died 5th week
34	Langley	1943	Traumatic	Distal I	23	Ligation I, C & S	Died in 16 hr. of shock, hemiplegia & pulmonary edema
35	Elkin	1945	Traumatic, arterio-venous	I artery, both I veins	25	Ligation I, artery proximally & distally, ligation I vein distally	Cure
36	Trent	1944	Spontaneous	I involving origin	52	Rubber band partial ligation I	Clinical cure; follow-up 10 mo.
37	Lindskog	1945	Traumatic	Distal I	25	Ligation I, preliminary ligation C	Well
38	Shumacker	1945	Traumatic	Distal I	25	Ligation I, C,S, sac evacuated	Cure, follow-up 18 mo.; had preliminary partial ligation with fascia & cellophane & sympathectomy

those who survived 55.6; in the more recent group the average age of the patients who died was 47.3 and that of those who survived about the same, 46 years. To inquire further into the cause of death it will be noted that one patient is said to have died of tracheal obstruction, one of uremia, two of infection, three of cerebral ischemic difficulties, and 8 of hemorrhage or shock. Of the patients who died from hemorrhage or shock, infection played a role in the fatal outcome in three, a pulmonary complication in another, and hemiplegia and pulmonary edema in a third. In three cases the cause of death is not stated, although it appears that hemorrhage and shock were the primary factors in at least two of them. Thus, the commonest difficulty has been hemorrhage at operation, or secondary hemorrhage later. It can be anticipated that adequate operative exposure, gentle dissection of the vessels, and proper use of blood transfusions may reduce the hazard of bleeding. Undoubtedly, with aseptic technique, chemotherapy, and antibiotics, infection should occur infrequently. The cerebral difficulties will remain a danger but can possibly be reduced to a minimum by repeated preoperative compression of the carotid until the patient can withstand such occlusion for a long period of time.

It will be noted that six of the cases of arterial aneurysm were traumatic in origin and thirty were due to either syphilis or arteriosclerosis. As might be expected, the mortality was less in the traumatic cases (16.7 per cent) than in those of spontaneous aneurysm (53.3 per cent). There were two traumatic arteriovenous fistulas; one patient died, one was cured.

In analyzing the various procedures which have been employed, it is noted that in five instances attempts at ligation were unsuccessful, and that all five patients died. Two of three patients had previously undergone ligation of the carotid and subclavian arteries. In eleven cases the innominate artery was ligated proximally. Six of the eleven died. One who survived had a metal band placed about the carotid artery afterward but was apparently unimproved until shortly before his death, eleven months later. Four of those who survived were said to have been cured or relieved of symptoms, although in one recurrence took place early and was successfully treated later by ligation of the innominate, carotid, and subclavian arteries and excision of the sac. In one patient the innominate artery was divided between ligatures; he died of hemorrhage on the third day. In six patients the innominate was partly constricted proximally, three times with a metal band, once with a rubber band, once with fascia, and once with fascia and cellophane. One of the first three died and two recovered; the result in these two patients is not cited. The fourth was apparently cured following partial proximal occlusion with a rubber band. The fifth apparently had little or no effect from partial occlusion and was cured three and one-half months later by ligation of the innominate, carotid, and subclavian arteries with opening and evacuation of the sac. Another was treated by partially constricting fascial bands about the innominate and carotid; he was improved although pulsation of the aneurysm persisted. A good result was obtained in one patient from suture of the rent in the artery after opening the sac.

Six patients were treated by ligation of the innominate and carotid arteries; four died and two recovered. In one of the two successful cases the carotid artery was ligated as a preliminary measure. In two of the fatal cases the carotid was ligated after the original operation. Another patient has been previously mentioned in whom a poor result followed ligation of the innominate artery and subsequent partial occlusion of the carotid. In two cases the innominate and subclavian arteries were ligated, with cure of the aneurysm. Seven patients were treated by ligation of the innominate, carotid, and subclavian arteries. In one of these the sac was partially removed, in one it was opened and its contents evacuated, and in one the sac was excised. One patient died. In five cases the aneurysm was apparently cured although a paresis occurred in one, while the seventh patient had a recurrence eight years later with rupture and death. In this last case the ligation of the carotid and subclavian arteries was performed after the innominate had been ligated; in the others the ligations were all done in one session. As has been mentioned, two of the patients had been operated upon before, one having had little or no effect from a partial innominate ligation, the other having had a prompt recurrence after complete innominate ligation. There were two cases of arteriovenous fistulas. One patient was treated by proximal and distal ligation of the vessels with cure, the other by transvenous suture of the artery and ligation of the vein with a fatal outcome. These data are summarized in Table II.

TABLE II. ANALYSIS OF RESULTS OF VARIOUS OPERATIVE PROCEDURES

OPERATION	NUMBER OF CASES	DEATHS	UNIMPROVED	IMPROVED AND CURED	RESULTS NOT STATED
*Arterial Aneurysms**					
Attempted ligation†	5	5			
Proximal ligation	11	6	1	4‡	
Partial proximal ligation§	6	1	1	2	2
Suture of artery	1			1	
Ligation of innominate and carotid	6	4		2	
Ligation of innominate and subclavian	2			2	
Ligation of innominate, carotid, and subclavian‖	7	1		6	
Arteriovenous Fistulas					
Transvenous suture; ligation of vein	1	1			
Proximal and distal ligation of artery and distal ligation of vein	1			1	

*Not counting preliminary carotid or subclavian ligations there were 38 operations upon 36 patients.

†One had previous carotid and subclavian ligation.

‡One recurred.

§One had also partial carotid ligation.

‖The sac was opened and evacuated in one, partially excised in one, excised in one. In one case recurrence took place 8 years later with rupture and death.

In each category there are two few cases to permit a comparison of the safety and effectiveness of the various methods of treatment. It goes without saying that if the artery could be safely and securely repaired this would be the procedure of choice but it is likely that this method will be found applicable

only in rare instances. Taking into consideration the data reviewed together with experiences in the surgical treatment of peripheral aneurysms, it would appear that the best procedure from the standpoint of safety to the patient and likelihood of cure of the lesion is proximal and distal ligation, combined when feasible with excision of the sac or evacuation of its thrombus. In most instances the distal ligation will involve ligation of the carotid and subclavian arteries. In these cases as in all instances of arterial surgery it will be wise when possible to divide and transfix the arteries rather than to ligate in continuity. Although the matter is still controversial, it is my policy to ligate the concomitant vein when occlusion of a major artery is necessary.

I have already mentioned the danger of cerebral ischemia and its possible reduction through repeated testing of the patient's ability to withstand prolonged carotid compression. In certain instances it may be advisable to perform a preliminary ligation of the carotid artery with a removable metal band, or fascial or tape ligature. As Lindskog[3] has pointed out, no case of gangrene of the upper extremity has been reported, although other evidences of ischemia have been observed not infrequently. In my patient temporary occlusion of the innominate rendered the hand pale, cold, and apparently bloodless. It would be wise to test the collateral circulation by observing the hand during temporary occlusion of the artery in every case before proceeding with permanent ligation, and to employ means of increasing the efficiency of the collateral circulation when necessary.

It is of significance that all save two of the patients treated by direct surgical attack had lesions involving the mid or distal portions of the innominate artery. In one of these the patient died before ligation could be accomplished. Only in the case of Trent was the outcome successful when the lesion involved the origin of the vessel.[5] Although the result in Trent's patient was excellent, in general, when the first portion of the innominate artery has been affected such procedures as ligation have not been found practicable. I know of no other successful case, but several unreported fatalities following attempt at such treatment have come to my attention. Unless the rubber band constriction which Trent used should prove the answer to this problem, and the experience with its use in aneurysms of the aorta would suggest that it may sometimes end in disaster, some other more indirect effort to control the aneurysm must be adopted in such cases. Thus far I have not mentioned such measures as Babcock's surgical production of a carotid-jugular arteriovenous fistula,[6, 7] distal ligation of the carotid and subclavian arteries employing the principle of Brasdor-Guinard, nor wiring of the aneurysms. Matas[8] has commented upon the hazards of performing the Babcock procedure and upon the functional difficulties which may follow it. I do not believe it has a place in the surgical treatment of innominate aneurysms. Although some excellent results have been reported with the technique of Brasdor-Guinard[9, 10] and though it may be applicable in rare cases, it would appear to be associated with definite risk and with only a moderate chance of relief of symptoms. In cases in which direct surgical attack has not proved feasible, I have felt that wiring and coagulation is the procedure of choice. I have used this method as developed by Blakemore and

King[11] in several cases in which the aneurysm involved the origin of the innominate. This procedure often brings about arrest of expansion of the aneurysm and relief of symptoms, although it cannot be considered a curative measure. It is entirely possible that a combination of wiring and coagulation with distal ligation of the carotid and subclavian arteries may yield better results than wiring and coagulation alone. Once the sac wall has been reinforced by an increase in the intramural thrombus following this procedure there should be little hazard associated with distal ligation, while after distal ligation there should be a good possibility of obtaining complete saccular thrombosis with further wiring—an accomplishment practically impossible with wiring alone. This plan at least deserves trial and it is my intention to test its worth when the opportunity presents itself.

SUMMARY AND CONCLUSIONS

A case of surgical cure of an innominate aneurysm has been reported and the literature has been briefly reviewed. It appears that direct surgical attack upon innominate aneurysms will necessarily be largely limited to those cases in which the origin of the artery is not involved. The best procedure which will ordinarily be found to be applicable in these cases would seem to be proximal and distal ligation combined with excision of the sac if possible, or evacuation of its contents. For those cases involving the origin of the innominate, wiring and coagulation, possibly combined with distal ligation, is probably the safest procedure offering the likelihood of a satisfactory result.

REFERENCES

1. Greenough, J.: Operations on Innominate Artery. Report of a Successful Ligation, Arch. Surg. **19:** 1484-1544, 1929.
2. Rundle, F.: Aneurysm of Innominate Artery Treated by Surgery: Report of 3 cases and records of 22 cases collected From Literature, Brit. J. Surg. **25:** 172-190, 1937.
3. Lindskog, G. E.: The Surgery of the Innominate Artery, New England J. Med. **235:** 71-76, 1946.
4. Shumacker, H. B., Jr.: Operative Exposure of the Blood Vessels in the Superior Anterior Mediastinum, Ann. Surg. (In press.)
5. Trent, E. R.: Ligation of the Innominate Artery for Innominate Aneurysm Using Rubber Bands: Report of a Case, Surg., Gynec. & Obst. **82:** 463-470, 1946.
6. Babcock, W. W.: A New Treatment for Thoracic Aneurysm, Ann. Clin. Med. **4:** 933-942, 1926.
7. McCarthy, P. A.: Treatment of Aneurysms of Thoracic Aorta and Innominate Artery by Distal Arterio-venous Anastomosis, Ann. Surg. **91:** 161-196, 1930.
8. Matas, R.: On the Treatment of Aortic Aneurysm by the Method of Jugulo-Carotid Anastomosis: A Discussion, New Orleans M. & S. J. **84:** 448-454, 1931.
9. Baldwin, J. F.: Aneurysm of the Innominate; Synchronous Ligation of Subclavian and Common Carotid With Long Survival; Unusual Incision, Am. J. Surg. **5:** 517, 1928.
10. Schwyzer, A.: Aneurism of the Innominate Artery, Ann. Surg. **96:** 666-669, 1932.
11. Blakemore, A. H., and King, H. G.: Electrothermic Coagulation of Aortic Aneurysms, J. A. M. A. **111:** 1821-1827, 1938.

THE USE OF TETRAETHYLAMMONIUM CHLORIDE IN THE TREATMENT OF EXPERIMENTAL ACUTE ARTERIAL INSUFFICIENCY

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IN THE treatment of acute arterial injuries of the major vessels, attention is immediately directed toward two objectives: controlling hemorrhage and overcoming the resultant acute arterial insufficiency to the tissues normally supplied by the artery and its branches.

The circulation is normally re-established by means of collateral circulation, in which pre-existing channels undergo dilatation and establish an alternate shunt around the site of injury. This restoration of blood flow may or may not be adequate, depending upon the vessel involved and the level of interruption. The arterial insufficiency may be manifest by coolness, trophic changes, decreased functional tolerance, ulceration, and gangrene. Therapy, in most instances, must be directed toward augmentation of the secondary, or collateral, circulation.

Numerous authors[1-6, 13] have pointed out that inadequacy of the collateral circulation, notwithstanding injury to these vessels, is frequently due to an element of vasospasm, which acts to diminish the caliber of these vessels. This active vasomotor tone is the direct result of an outflow of vasopressor impulses from an intact sympathetic nervous system. The normal tone maintained in health is further increased by reflex spasm resulting from the proximate arterial injury. It has been demonstrated clinically and experimentally[1-4, 6, 13] that interruption of this sympathetic outflow by various methods results in an increased blood flow through collateral channels, as evidenced by a rise in skin and deep temperatures, decreased venous filling time, increased oscillometric readings, and the prevention of tissue death.

Leriche and Stricker and Orban in a series of experiments[1, 2] proved conclusively the value of sympathectomy in the prevention of massive gangrene and death following extensive arterial resections in animals. They found that following resection of the terminal aorta and its branches in the dog, more than four-fifths of their animals died in twenty-four hours to four days with paralyzed, cold, cyanotic, and edematous hind limbs. If, however, bilateral lumbar sympathectomy was performed at the same time just prior to the arterial resection, the animals showed little ill effects. Within twenty-four hours they could stand and walk, with warm hind limbs and little evidence of circulatory insufficiency. At the end of a week, they were as active as normal animals.

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*Life Insurance Medical Research Fellow.

Reichert[14] has excellently demonstrated the collateral channels which enlarge following ligation of the aorta in dogs by the injection of a roentgenographically opaque mass. He has stated that the abdominal aorta can be ligated without danger of gangrene.

Brooks[7] has shown that, following experimental ligation of the abdominal aorta below the inferior mesenteric artery and without excision and division, there is always definite evidence of impairment of circulation. In most instances he reported evidence of impaired function and, in a few instances, gangrene of the feet. A considerable number of his animals died after ligation of the aorta without any known cause.

Recently, reports have appeared concerning the pharmacologic action of the tetraethylammonium ion upon the sympathetic nervous system. This drug acts chiefly to block, at the autonomic ganglia, the transmission of sympathetic and parasympathetic nerve impulses. The pharmacology has been reviewed in detail by Acheson and Moe.[8-10] Proof was afforded that the chief, if not the sole, locus of action of tetraethylammonium ion is at the autonomic ganglia. The intravenous administration of vasodepressor doses of the drug causes an increase in blood flow through the femoral artery.

The following series of experiments was undertaken to determine the efficacy of chemical sympathetic blockage in experimental acute arterial injuries. No attempt has been made to compare results of treatment with the tetraethylammonium ion with other methods of sympathetic interruption.

EXPERIMENTAL METHOD

Since the result of aortic ligation alone is variable as to survival of the animal or gangrene of the posterior extremities, and since various authors have reported varying percentages of deaths following excision of the trifurcation of the aorta, in this series a more extensive resection was carried out. The operation was extended to include the deep circumflex iliac vessels which constitute one of the major collateral channels following aortic ligation. If these vessels had their origin above the inferior mesenteric artery, they were ligated and divided at that point. In this manner, the arterial supply to the extremities was reduced to a critical level.

A group of thirty adult mongrel dogs, weighing from 9 to 15 kilograms, was selected. Identical operative procedures were carried out on all animals in the group. Surgical anesthesia was obtained by the intravenous administration of sodium pentobarbital, 64 mg. per five pounds body weight. Under aseptic precautions, the aortic trifurcation was exposed. The terminal aorta was doubly ligated distal to the origin of the inferior mesenteric artery, but proximal to the origin of the deep circumflex iliac arteries. Ligatures were placed around the two external iliac arteries and the common hypogastric trunk. The intervening arterial trunks were excised. The abdominal wound was closed in layers.

In the control group of ten dogs, nothing further was done, the animals being closely observed until the time of their death, following which autopsy was performed.

In the experimental group, administration of tetraethylammonium chloride* was begun immediately after excision of the arteries. This was given in the proportion of 25 mg. per kilogram body weight, as a sterile 10 per cent

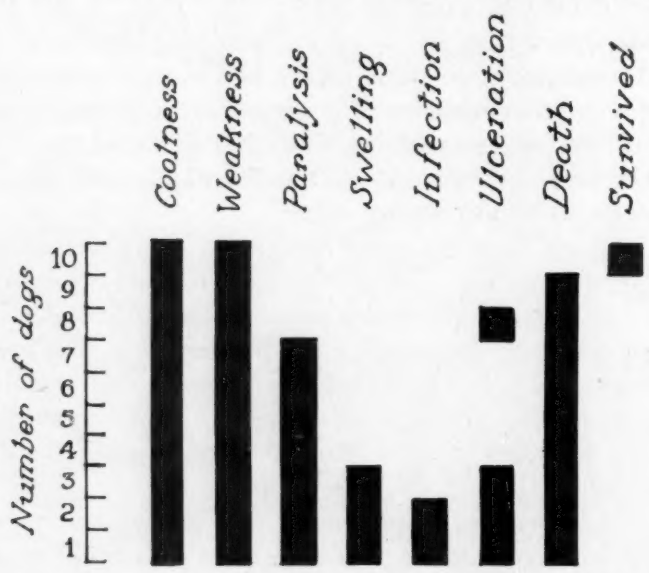


Chart I.—Results of aortic excision in untreated animals.

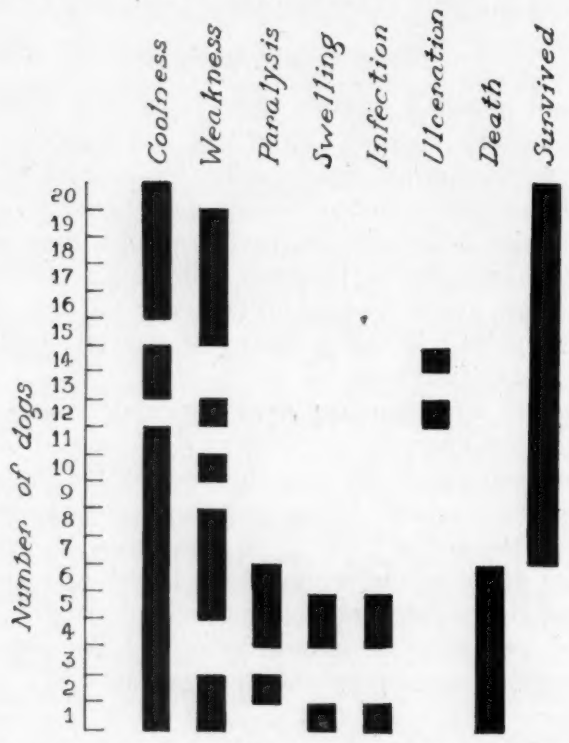


Chart II.—Results of aortic excision in animals treated with tetraethylammonium chloride.

*Supplied as Etamon, by the Parke, Davis & Company, Detroit, Mich.

solution, intramuscularly. Similar doses were given every eight hours for three days.

All the animals were allowed food, water as desired, and offered exercise at least once daily, as tolerated.

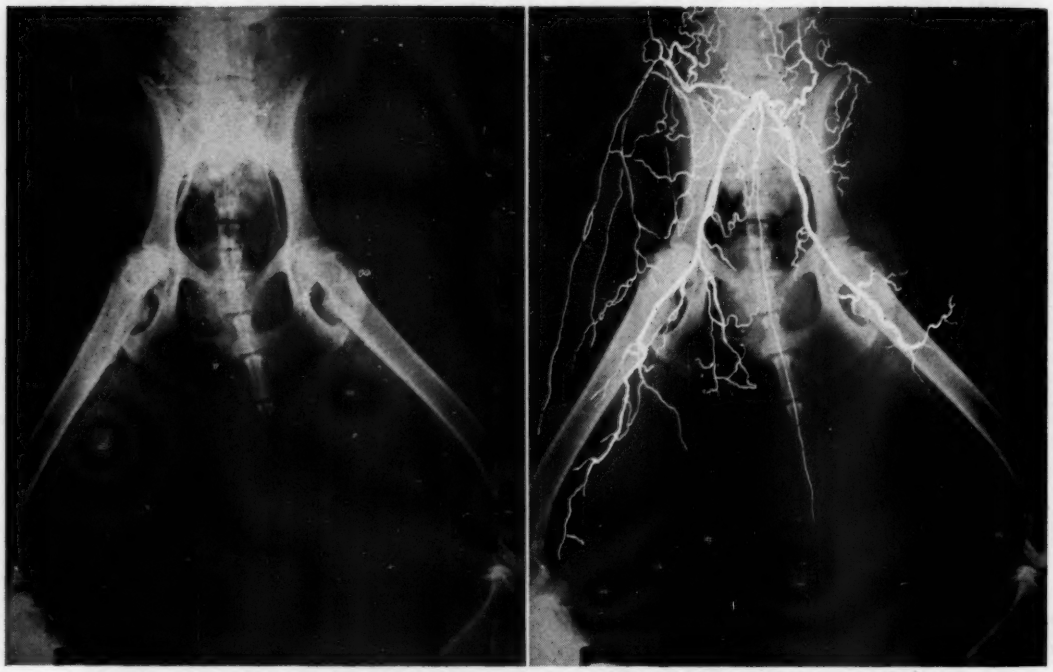
RESULTS

In the control group, nine of the animals died within twenty-four hours to seven days. The majority of deaths were within a four-day period. Autopsy revealed in each instance that death was not due to hemorrhage from the ligated arteries or to peritoneal infection. Prior to their death, these animals exhibited the same findings as reported by Leriche: hindlimb paralysis, coldness, cyanosis, and varying degrees of swelling.

Fig. 1.—*A*, Arteriogram immediately following ligation of the terminal aorta, little filling of the collateral vessels occurs. *B*, Arteriogram following injection of thorotrast into the aorta of a normal dog.

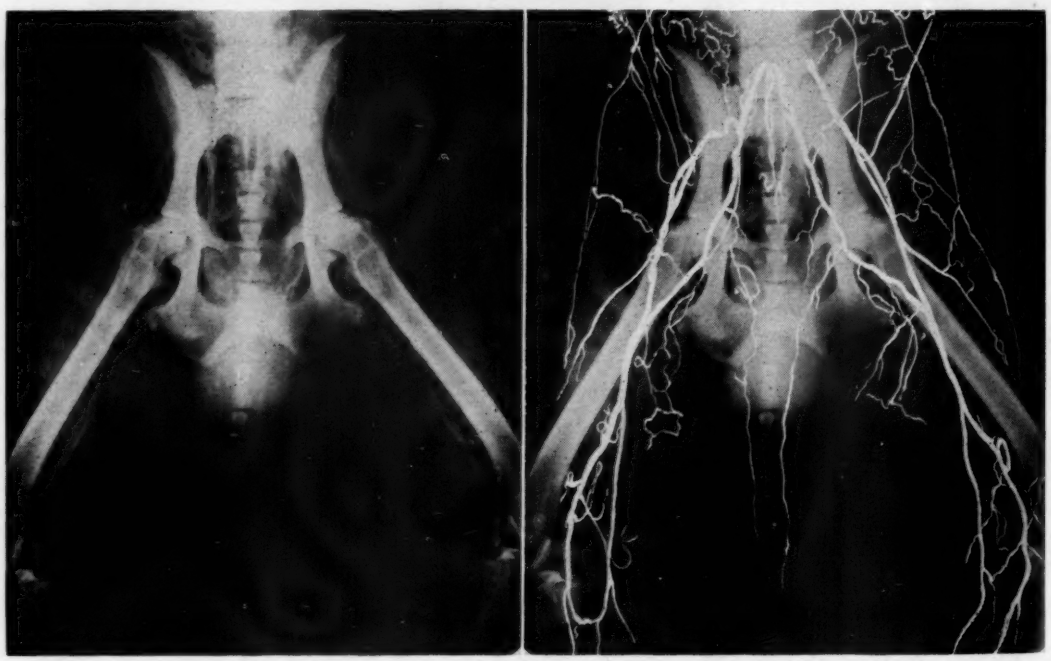
In the group of twenty animals treated with tetraethylammonium chloride, fourteen of the animals survived. These animals regained excellent functional activity within two to six days. Of the remaining six dogs which died, three deaths were the result of infection of a posterior extremity. One of the remaining animals died within twelve hours of operation, and the other on the tenth postoperative day from an undetermined cause.

Arteriograms were performed immediately following ligation and excision of the aorta in control animals (Fig. 1, *B*). In such instances there was little filling of the collateral channels by the contrast media. In the animals which survived, following tetraethylammonium chloride therapy, a graded increase in filling of the vessels could be roentgenologically demonstrated (Figs. 2 and 3).



A. *B.*

Fig. 2.—*A*, Arteriogram seven days following excision of the trifurcation of the aorta and postoperative treatment with tetraethylammonium chloride. The deep circumflex iliac vessels are filled as are the internal iliacs. *B*, Retouched roentgenogram.



A. *B.*

Fig. 3.—*A*, Arteriogram fourteen days following aortic excision and tetraethylammonium chloride therapy. The femoral vessels fill readily. *B*, Retouched roentgenogram.

DISCUSSION

The results obtained from chemical blockage of autonomic ganglia are thought to be due to a removal of vasomotor constriction of collateral vessels, thus permitting their dilatation. In these experiments the immediate time interval following arterial resection, referred to by Leriche as "the critical period," appears to be the optimum time for removal of vasomotor constrictor impulses. Once an increased collateral circulation is established, it is able to maintain itself, and probably undergoes a graded increased over later intervals, as evidenced by the increased tolerance for daily exercise.

In view of these experimental results, it is suggested that tetraethylammonium chloride may become a valuable adjunct in the clinical treatment of acute arterial injuries involving major vessels.

SUMMARY

1. The rationale for sympathetic interruption following acute arterial injury is presented.

2. Experimental observations have been made which indicate that chemical blockage of autonomic ganglia by tetraethylammonium ion may be of value in acute arterial insufficiency following arterial injury both as a substitute for other methods of sympathetic interruption or as a preliminary to them.

REFERENCES

1. Leriche, R.: Experimental and Clinical Basis for Arteriectomy in the Treatment of Localized Arterial Obliterations, Am. J. Surg. **14**: 55, 1931.
2. Stricker, P., and Orban, F.: Recherches experimentales sur la thrombose arterielle, les arterites, la gangrene, et sur la valeur comparee des ligatures arterielles et des arteriectomies, J. de chir. **36**: 697, 1930.
3. Mulvihill, D. A., and Harvey, S. C.: Studies on Collateral Circulation. I. Thermic Changes after Arterial Ligation and Ganglionectomy, J. Clin. Investigation **10**: 423, 1931.
4. deTakats, G.: Neurovascular Lesions of the Extremities, Bull. Am. Coll. Surgeons **28**: 139, 1943.
5. Coller, F. A., and Maddock, W. G.: The Function of Peripheral Vasoconstriction, Ann. Surg. **100**: 983, 1934.
6. Ochsner, A.: Indications and Technique for the Interruption of Impulses Traversing the Lumbar Sympathetic Ganglia, S. Clin. North America **23**: 1318, 1943.
7. Brooks, B.: Ligation of the Aorta: An Experimental Study, Tr. South. S. A. **39**: 228, 1926.
8. Acheson, G. H., and Moe, G. K.: Some Effects of Tetraethylammonium on the Mammalian Heart, J. Pharmacol. & Exper. Therap. **84**: 189, 1945.
9. Acheson, G. H., and Moe, G. K.: The Action of Tetraethylammonium on the Mammalian Circulation, J. Pharmacol. & Exper. Therap. **87**: 220, 1946.
10. Acheson, G. H., and Pereira, S. A.: The Blocking Effect of Tetraethylammonium Ion on the Superior Cervical Ganglion of the Cat, J. Pharmacol. & Exper. Therap. **27**: 273, 1946.
11. Lyons, R. H., Moe, G. K., Neligh, R. B., Hoobler, S. W., Campbell, K. N., Berry, R. L., and Rennick, B. R.: The Effects of Blockade of the Autonomic Ganglia in Man, Univ. Hosp. Bull., Ann Arbor **12**: 33, 1946.
12. Berry, R. L., Campbell, K. N., Lyons, R. H., Moe, G. K., and Sutler, M. R.: The Use of Tetraethylammonium in Peripheral Vascular Disease and Causalgic States. A New Method for Producing Blockade of the Autonomic Ganglia, SURGERY **20**: 525, 1946.
13. DeBakey, M. E., and Simeone, F. A.: Battle Injuries of the Arteries in World War II. An Analysis of 2,471 Cases, Tr. South. S. A. **57**: 65, 1945.
14. Reichert, F. L.: An Experimental Study of the Anastomotic Circulation in the Dog, Bull. Johns Hopkins Hosp. **35**: 385, 1924.

THE ACTION OF HEPARIN ON EXPERIMENTAL VENOUS THROMBOSIS

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THE extensive clinical trial of heparin, both here and abroad, in the prophylaxis and treatment of venous thrombosis has stimulated our interest in those properties of heparin which relate directly to this problem. The purpose of this paper will be to elaborate upon the in vivo action of heparin on the preformed clot.

The possibility that heparin might prevent vascular thrombosis was first enunciated by Howell.[1] Mason[2] in 1924 showed that heparin will prevent the formation of an intravascular clot induced by the injection of potent thrombokinase into the blood stream. Experimental evidence indicating that heparin will protect against the intravascular thrombosis which ordinarily would occur after traumatic and mechanical means has been reported by Murray and his co-workers,[3] Best, Cowan, and MacLean,[4] and by Rabinovitch and Pines.[5] There is, however, a considerable variation of opinion as to the effect of heparin on the preformed clot. This may be ascribed to the different methods of inducing thrombosis, to the varying strengths of heparin used, and, finally, to the modes of administration of this agent. It would be fitting at this point to review the major experimental work on this most controversial subject.

The acknowledged failure of heparin to act on the in vitro clot is readily demonstrable and has recently been reaffirmed by Rabinovitch and Pines. However, the in vivo clot has, on occasion, been seen to disappear. This startling contrast between in vivo and in vitro action has stimulated many observers to determine, if possible, the precise action of heparin in the living organism since the in vivo anticoagulant property of heparin is fraught with therapeutic possibilities. In a series of experiments inaugurated in 1932 and reported in 1937 by Murray, Jaques, Perrett, and Best,[3] thrombosis was initiated in veins of dogs by either mechanical or chemical trauma. The mechanical trauma was accomplished by crushing a vein over an intraluminal silk thread with a hemostat, following which the thread was removed and the wound sutured. Occluding thrombi appeared in seven hours to seven days in 80 per cent of the cases. Chemical trauma was effected by the introduction and retention of soricin in the vein for three minutes. By this method, 85 per cent of the veins were thrombosed. Heparin was given for varying periods before and after trauma. Trauma following prophylactic heparin administration resulted in a few minimal thromboses, the majority of veins remaining

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patent if additional heparin was given subsequently. Heparin given after trauma maintained the patency of a number of veins, the percentage of patent vessels being inversely proportional to the length of time ensuing between trauma and inception of heparin therapy.

To summarize all the recorded experiments, 14 per cent of the control veins were patent after mechanical trauma while 81 per cent of the test veins were patent when heparin was administered for seventy to seventy-two hours. Similarly, with chemical trauma, 15 per cent of the controls were patent while patency was maintained in 53 per cent of the heparinized veins.

The experimental evidence that heparin did have some effect on the preformed clot was further bolstered by the results of Solandt and Best,[6] who showed that coronary thrombosis could be induced by soricin in twelve of thirteen control dogs while similar lesions occurred in only one of twelve dogs if heparin was given continuously for twenty-four hours after injury. Further evidence was brought forth by Rabinovitch and Pines[5] whose method of inducing thrombosis consisted of stretching the vein, thus causing endothelial damage. A constricting silk ligature was then used to occlude the lumen partly. Heparin was subsequently administered in bidaily intravenous doses for five or six days. These investigators showed that, in certain instances, heparin caused the disappearance of the thrombus only in the early stages and never when the clot had already been organized.

To recapitulate: (1) If heparin was given previous to trauma and continued for a variable period afterward, thromboses were infrequently observed. (2) Heparin administered up to three days after trauma caused disappearance of the clot in a considerable percentage of cases. (3) Heparin administered when the clot was organized resulted in no demonstrable dissolution of the clot.

It occurred to us to determine, if possible, at what stage of clot formation heparin administration would result in solution of the clot and what effect, if any, heparin had on the organizing clot.

METHODS

Induction of Thrombosis.—Experimental venous thrombosis has hitherto been accomplished by chemical and mechanical means. Although Murray and his co-workers reported 80 to 85 per cent successful thromboses with their methods, the 15 to 20 per cent margin of error seemed too great for critical evaluation. Similarly, in our hands, stretching the vein by the method of Rabinovitch and Pines was not successful in the majority of cases. It is obvious from both the experimental work on thrombosis and the theoretical considerations of blood coagulation, that the elaboration of a successful thrombus depends on: (a) stagnation of blood, (b) injury to the intima, (c) release of considerable amounts of thrombokinase from the vessel walls. After numerous trials a method of experimental induction of thrombosis was devised which fulfills all the requirements set forth previously and which is uniformly successful.[7] Three kilogram rabbits are anesthetized with ether and a midline cervical incision is made. The jugular veins on either side are exposed, both

veins being treated alike. A 3 cm. segment of vein is dissected free and the most proximal portion is securely tied with a silk ligature. A flat, narrow strip of metal, such as a ribbon retractor* is placed under the vein distal to the ligature and acts as an anvil. The vein is then given fifteen to thirty sharp taps with the handle of a Mayo scissors. Brisk bleeding will occur, which is readily controlled by gauze pressure. Care is taken not to fracture the vein completely across. When bleeding has ceased, usually in about two minutes, a palpable and visible clot appears. If this does not occur, the procedure is again repeated. Clotting invariably is present after the second series of strokes. All animals are re-examined after forty-eight hours to reaffirm the presence of clots.

Heparinization.—The method of continuous heparinization as reported by Murray and his co-workers is obviously impractical in animals if heparinization is to be continued for long periods of time. Similarly, intermittent heparinization is not consistently effective in that the coagulation time may well fall to normal levels in the interval between successive doses of heparin. As a matter of fact, the coagulation time may undergo a diphasic reaction and induce a state of hypercoagulability. Because of these objections we were constrained to use the heparin/Pitkin menstruum preparation.[8]† The Pitkin menstruum is a gelatin-base medium which was designed to regulate and retard the release of water-soluble drugs incorporated within it. The preparation with varying amounts of heparin has been extensively used on human patients with uniformly excellent results.[9, 10, 11] The formulas employed in our experiments contained vasoconstrictors which further delayed the absorption of the heparin and prolonged the effect of a single dose. The dosage has varied from 40 to 100 mg. of heparin given every two to three days. The amount was governed solely by the coagulation time, which was maintained at two to four times the normal level. Coagulograms were determined by a modification of the Lee-White method which has been completely described elsewhere.[10] No hemorrhages were encountered in our series.

EXPERIMENTAL RESULTS

From Table I, the scope of the experiment is evident. Thrombosis was induced in both jugular veins of 3 kg. rabbits by the method described. In all instances except the one-day animals, the veins were examined after forty-eight hours to determine the presence or absence of thrombosis. In our earlier work, absence of clot was noted on occasion so that thrombosis had to be re-induced. With improvement in our techniques, as evidenced by the last 99 veins, reported in Table I, no failures were encountered. At variable periods after the induction of thrombosis, if the forty-eight hour re-examination proved to be satisfactory, the wound was opened and the left jugular vein removed for control microscopic section. The animal was then heparinized for six to fourteen days, after which the wound was again opened, the lesion photographed, and the remaining jugular vein removed for microscopic study.

*We wish to thank Mr. E. J. Sovatkin of the J. Sklar Manufacturing Company, Long Island City, N. Y., for his generous gift of surgical instruments used in the animal experiments.

†Prepared and distributed by William R. Warner & Co., Inc., New York, N. Y.

TABLE I. THE ACTION OF HEPARIN ON THE PRE-FORMED CLOT IN THE RABBIT

HEPARIN						CONTROL				
DAYS AFTER TRAUMA AND BEFORE HEPARIN THERAPY	NUMBER OF VEINS	PERIOD OF THERAPY	PATENT	OCCLUDED	COLLATERALS	DAYS AFTER TRAUMA AND BEFORE HEPARIN THERAPY	NUMBER OF VEINS	PATENT	OCCLUDED	COLLATERALS
1	5	6	4	1	0	1	2	0	2	0
2	3	6	2	1	0	2	3	0	3	0
3	3	13	3	0	0	3	5	0	5	0
	1	6	0	1	0					
5	3	13	2	1	0	5	4	0	4	0
6	1	6	0	1	1	6	4	0	4	0
	2	13	1	1	1-2					
7	4	13	3	1	2					
8	3	13	0	3 (partly)	2	8	1	0	1	0
9	4	13	0	4 (partly)	2	9	4	0	4	0-1
10	1	13	0	1 (partly)	2-3	10	5	0	5	0-1
11	1	14	0	1 (partly)	3	11	2	0	2	1
	1	6	0	1	2					
13	3	14	0	3 (partly)	3	13	2	0	2	1
14	9	14	0	9	4	14	2	0	2	1
						15	1	0	1	1
						28	10	0	10	1-2
	44						45		45	

TABLE II

DAYS (INCLUSIVE) AFTER TRAUMA AND BEFORE HEPARIN THERAPY	DAYS OF HEPARIN	NUMBER OF VEINS	PATENT	OCCLUDED	COLLATERALS
1-5	6	9	6	3	0
	13	6	5	1	0

TABLE III

DAYS (INCLUSIVE) AFTER TRAUMA AND BEFORE HEPARIN THERAPY	DAYS OF HEPARIN	NUMBER OF VEINS	PATENT	OCCLUDED	COLLATERALS
6-7	6	1	0	1	1 plus
	13	6	4	2	1 plus

TABLE IV

DAYS (INCLUSIVE) AFTER TRAUMA AND BEFORE HEPARIN THERAPY	DAYS OF HEPARIN	NUMBER OF VEINS	PATENT	OCCLUDED	COLLATERALS
8-13	6	1	0	1	2 plus
	13	12	0	12 partly	2 plus and 3 plus

For the purposes of analysis, it is convenient to subdivide Table I into four sections; these subdivisions (Table II, III, IV, and V) relate to the heparinized animals and indicate the number of days from inception of trauma to the initiation of heparinization. Table II included the first through the fifth days, Table III the sixth through the seventh, Table IV the eighth through the thirteenth, and Table V included all of the fourteen-day animals.

From Table II (one to five days after trauma and before heparinization) it is evident that of nine veins with but six days of active heparinization, six were patent and three were occluded. Of six veins with thirteen days of heparinization, five were patent (Fig. 1) and one was occluded. No collaterals were observed. In the control nonheparinized group of fourteen veins, all fourteen were occluded (Fig. 2).

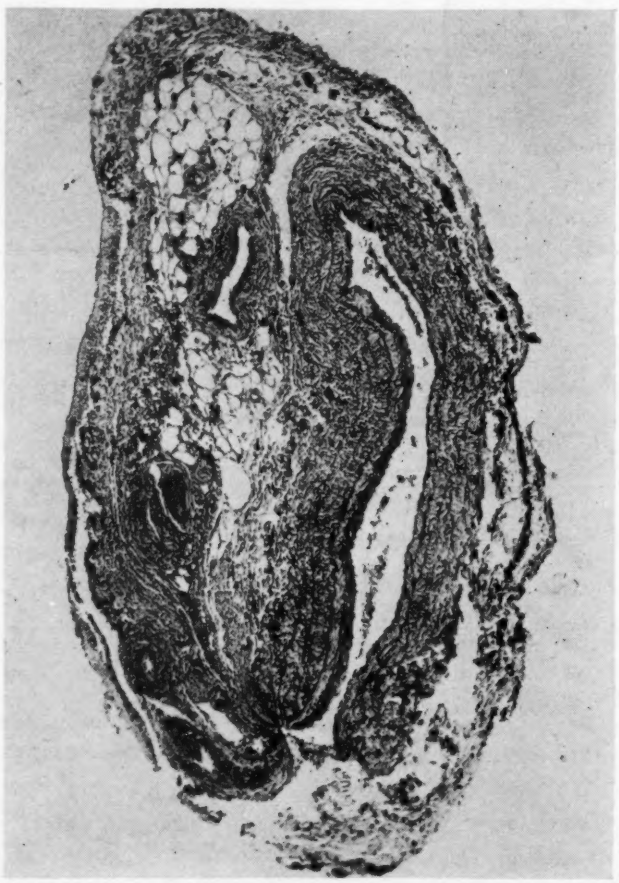


Fig. 1 (Rabbit 86H).—Two-day animal with eleven days of heparin. The lumen is empty. The wall is thin and the elastic tissue is well preserved. (Elastic Van Gieson ×70.)

Table III (six to seven days after trauma and before heparinization) reveals that of six veins heparinized for thirteen days, four were patent (Fig. 3) and two were occluded. Small, single collaterals were seen to parallel the heparinized vein, while none were seen accompanying the nonheparinized controls. All six of the control veins were occluded (Fig. 4).

Fig. 2 (Rabbit 82).—Two-day control; the lumen is distended and is filled with an early thrombus. The wall is thin and the elastic tissue is still fairly well preserved. (Elastic Van Gieson ×21.)

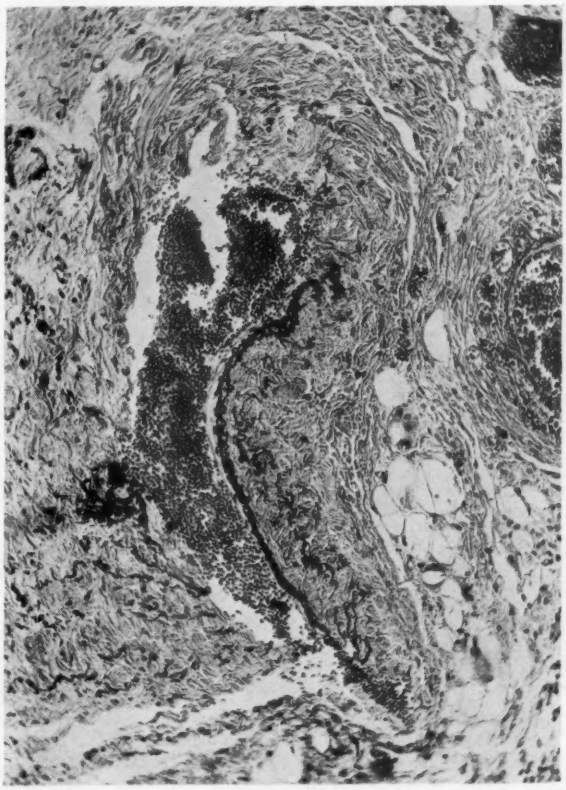


Fig. 3 (Rabbit 70H).—Six-day animal with twelve days of heparin. The lumen does not contain thrombi. The internal elastica is fragmented. (Elastic Van Gieson ×135.)

Fig. 4 (Rabbit 70).—Six-day control; the lumen is filled with a thrombus. The elastic tissue is fragmented and the various coats of the vessel wall are poorly differentiated. (Elastic Van Gieson ×40.)

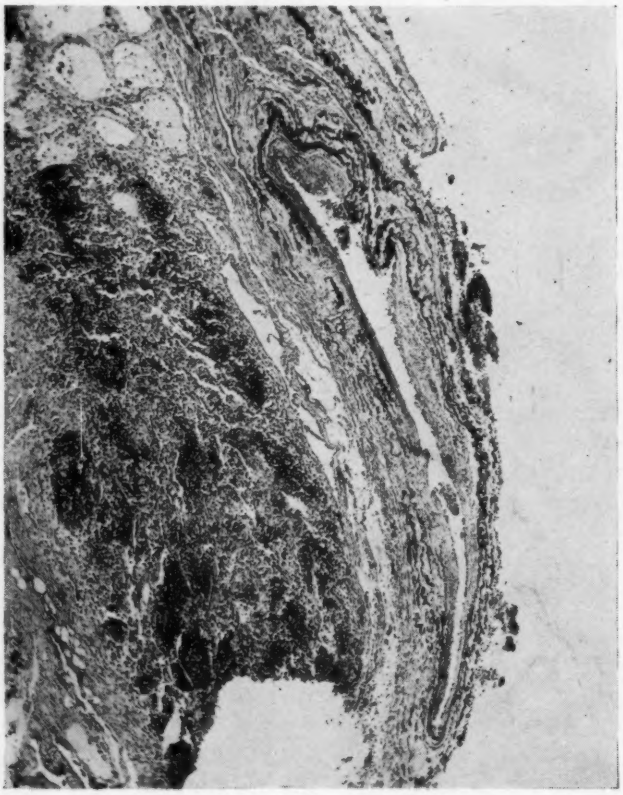


Fig. 5 (Rabbit 63H).—Nine-day animal with fourteen days of heparin. The lumen is narrow but empty. The intimal connective tissue is increased in amount. The elastic tissue is fragmented and reduplicated in places but appears to encircle the lumen. (Elastic Van Gieson ×40.)

Table IV (eight to thirteen days after trauma and before heparinization) was of considerable interest to us in that all the twelve veins which had been heparinized for thirteen days appeared clinically patent. The veins were thickened but blue and somewhat collapsible so that blood flow through these vessels were clinically obvious. However, on microscopic section, these presented various degrees of organization and recanalization (Figs. 5 and 6). One vein, examined after six days of heparinization, appeared to be a solid cord. All of the fourteen control veins were thickened, gray, noncollapsible structures which, on microscropic section, were seen to be organized with

Fig. 6 (Rabbit 61H).—Nine-day animal with thirteen days of heparin. The lumen contains a thrombus which is undergoing organization and recanalization. The elastic tissue is fragmented and reduplicated. (Elastic Van Gieson ×60.)

evidence of recanalization (Fig. 7). The extent of recanalization and the diameters of the recanalized lumina appeared greatest in the animals heparinized for thirteen days. The heparinized veins were accompanied by two to three fairly large collateral vessels, while the control veins of comparable age had one or, at most, two tiny to medium-sized collaterals.

Table V (fourteen days after trauma and before heparinization) represents nine veins heparinized for fourteen days. All of these were identified only by the encircling black silk ligature. The veins were gray, solid, threadlike struc-

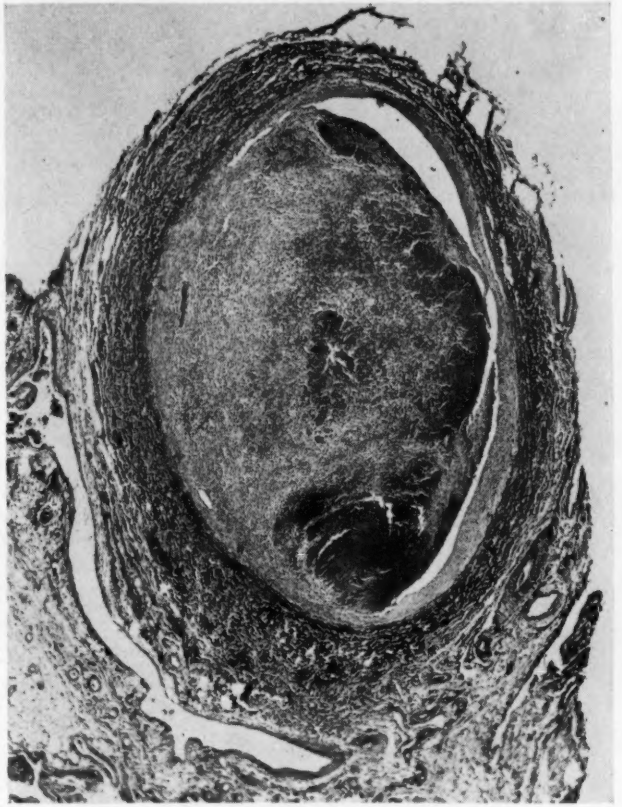


Fig. 7.

Fig. 8.

Fig. 7 (Rabbit 60).—Ten-day control animal. The lumen contains a thrombus which in places is being organized and recanalized. Areas of sludge formation are still present. (Elastic Van Gieson ×32.)

Fig. 8 (Rabbit 58H).—Fourteen-day animal with fourteen days of heparin. The lumen contains a large organized thrombus. The remainder of the lumen is recanalized in what appears to be a continuous channel. (Elastic Van Gieson ×70.)

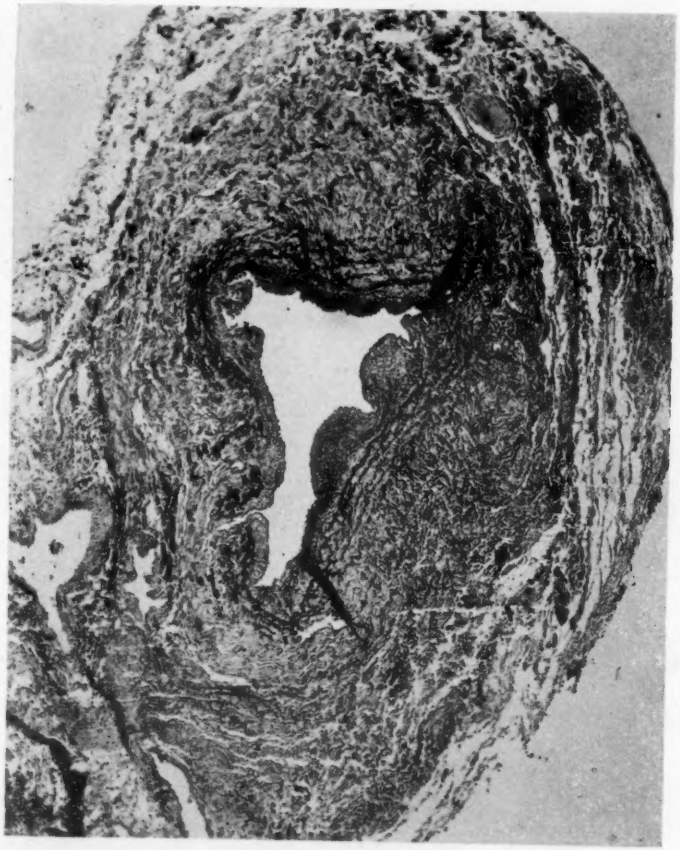


Fig. 9.

Fig. 10.

Fig. 9 (Rabbit 31B).—Fourteen-day animal with fourteen days of heparin. The lumen is narrow and empty. The internal elastic membrane is well defined, although fragmented in spots. The subintimal connective tissue is greatly increased in amount. (Elastic Van Gieson ×70.)

Fig. 10 (Rabbit 10B).—Twenty-eight day control animal. The various coats of the vessel wall are poorly demarcated. The elastic membrane is fragmented. The lumen is occluded by an organized thrombus in which recanalized channels of varying size are present. (Elastic Van Gieson ×70.)

tures which clinically seemed incapable of transporting blood. On section, these were well organized and contained large recanalized lumina (Figs. 8 and 9) and not the honeycombed pattern of recanalization so evident in the control mates of comparable interval after trauma (Fig. 10). Most interesting in this group were the collateral veins (Fig. 11). In the heparinized series, the collateral vessels were three to four in number, many as large as the original vein. Most often, they formed a complex anastomosis with vessels proximal to

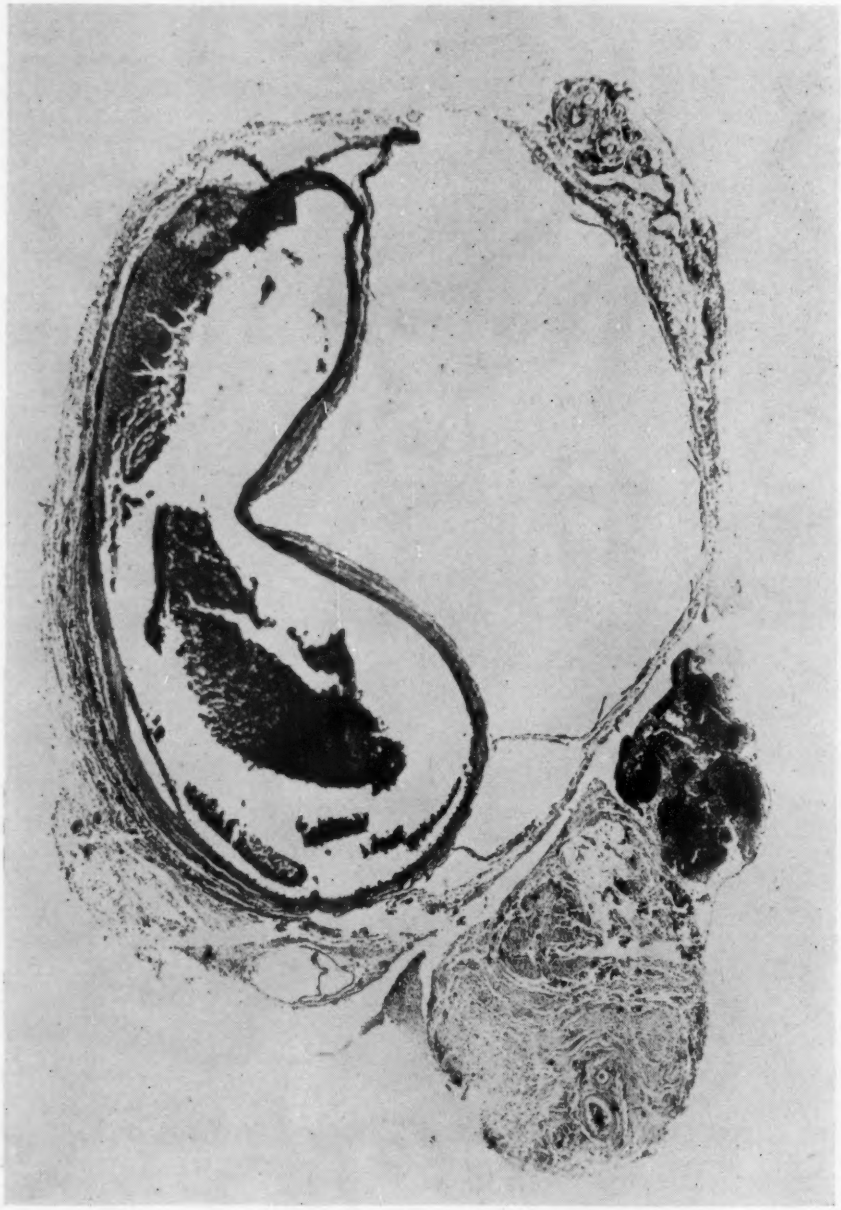


Fig. 11 (Rabbit 55A).—Collateral vein; fourteen-day animal with fourteen days of heparin. All the characteristics of a normal vein can be seen. (Elastic Van Gieson ×27.)

TABLE V

DAYS (INCLUSIVE) AFTER TRAUMA AND BEFORE HEPARIN THERAPY	DAYS OF HEPARIN	NUMBER OF VEINS	PATENT	OCCLUDED	COLLATERALS
14	14	9	0	9	4 plus

the restraining ligature. The control collaterals usually numbered one or two, were for the most part small (in comparison to the heparinized mates) and did not form the rich anastomotic network seen in the previous group.

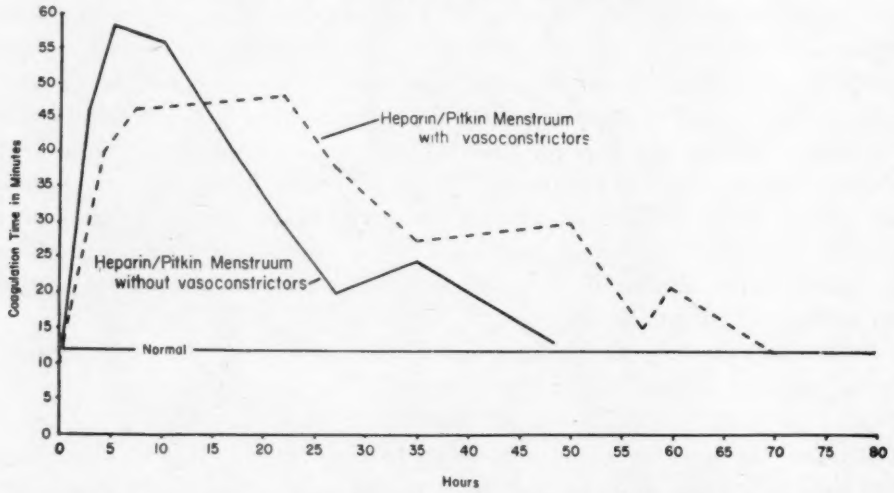
DISCUSSION

Several facts are immediately apparent from a study of Tables I to V. First, patency can be re-established in a number of experimental veins even as long as six days after a clinically visible and microscopically acceptable thrombus is present. Second, the extent and apparently the speed of recanalization is enhanced by the use of heparin. Third, when the vein is so occluded grossly as to preclude the resumption of clinical patency, recanalization is still greater in degree and extent under heparin therapy. Fourth, in the presence of occluded veins which cause definite obstruction to circulation, the opening of adjacent collateral venous channels is so extensive in the presence of heparin that the combined cross sectional area of the collateral system appears as great, if not greater, than that of the original vein.

These results are at variance with the published data of Murray and associates[3] and Rabinovitch and Pines.[5] The former group administered heparin for seventy-two hours after trauma while the latter, in one series, heparinized their animals for periods up to eight days. It is evident from our series that even eight days is too brief a period in which to extract the maximum benefit to be derived from heparin. Our fourteen-day period was arrived at after extensive experience with the heparin/Pitkin menstruum preparation in patients with thrombophlebitis and/or phlebothrombosis. Assuming the seventy-two hour period to be too brief beyond question, the failure of the eight-day period of Rabinovitch and Pines can be partly explained, first, by the fact that per se, eight days has been shown to represent too brief a span of heparinization; second, the heparin as used by them yielded a good anticoagulant effect for only five hours. Since their results were predicated on a bidaily schedule of heparin administration, there obviously must have been gaps in the treatment day when the coagulation time was at normal levels or, indeed, as we have seen repeatedly, the level may have fallen below normal thus inducing a state of hypercoagulability. Coagulograms utilizing heparin/Pitkin menstruum reveal that maximum effects are obtained in four hours and are continued for forty-eight or more hours (Graph 1). Reinjection every forty-eight hours obviously will consistently maintain the coagulation time well above normal limits.

Since it is well known that heparin in vitro has no effect on fibrin, it appears difficult to explain the dissolution of clots up to and including the sixth day after thrombus formation. Examination of our sections demonstrates

that organization occurs at a varying tempo despite the fact that the inducing trauma is severe and approximately equal in all instances. A critical review of the physical changes resulting in clot formation may afford a possible explanation of our results. The classical early red cell clot consists of red cells enmeshed in an interlacing fibrin network. After varying periods of time, organization occurs within the clot, wherein the red cells and fibrin are replaced by young fibrous connective tissue. This, in turn, may undergo one of two changes. The adherence of the organized clot to the vessel wall together with further organization of the clot by "mature" fibrous tissue may convert the originally patent vessel into a solid cord through which no blood flow is possible. The second possibility consists of essentially the same process with the additional factor of recanalization of the organized clot to a varying degree so that a minimal amount of the original blood flow is restored.



Graph 1.—Coagulograms demonstrating average prolongation of coagulation time following the administration of 50 mg. heparin/Pitkin menstruum.

In the light of recent work on the functional pathology of experimental frostbite[12, 13] and on the blood flow in Knowsley malaria and in traumatic shock,[14, 15, 16] it may be inferred that the natural history of the classical clot as described previously is not complete. In the presence of injury or infectious disease, Knisely and his co-workers have observed that red cells become "sticky" and adhere to one another, at first in small clumps which soon become progressively larger so that blood flow rapidly slows down and the blood itself appears as a thick mucky sludge, similar to the sludge phenomenon in experimental frostbite. The mechanism whereby the red cells become sticky is mediated through the formation of a thick, glassy, cottony precipitate whose appearance and consistency suggests that it might be fibrin or a fibrin-like material. This substance is not visible by transillumination in vitro but can readily be seen by dark-field illumination. It thus follows that the earliest stage of clot formation may well be represented by a large mass of red cells agglutinated to one another and not as yet exhibiting the usual interlacing fibrin net work. In point of fact, we have a number of sections taken from early, clinically well

thrombosed veins which, on microscopic examination, reveal no evidence of clot formation in the usual sense (Figs. 7 and 12). It is not surprising, therefore, that these clotted veins in the sludge stage may well be mistaken for normal red cell-containing veins. In the progressive growth of a clot, sludge formation is ever present, both as the propagating tail and as part of the unorganized body of the clot. It is significant that in every instance where pure sludge formation was noted microscopically, despite clinically palpable clot formation, the clot disappeared completely under heparin therapy.

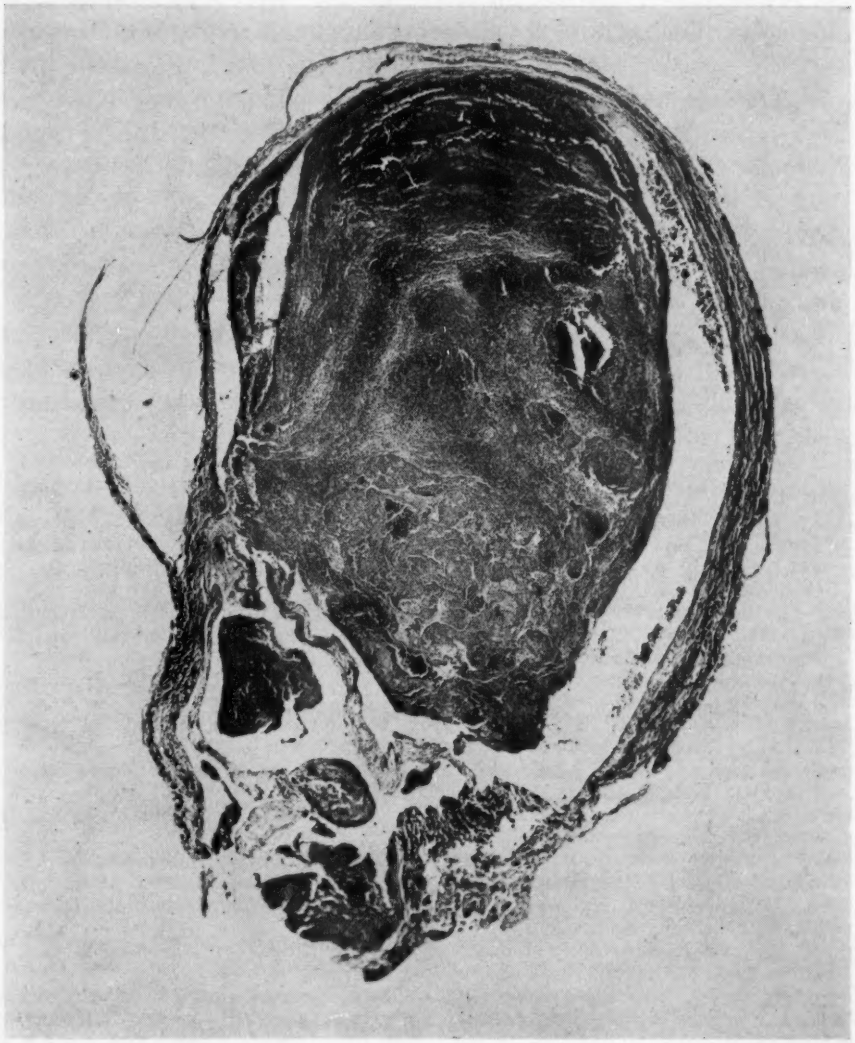


Fig. 12 (Rabbit 79).—Three-day control animal. The lumen is filled with a recent thrombus in which the lamination of the accepted early thrombus is not yet present. The blood cells are seen as individual members and have not as yet lost their identity. Here and there, evidence of beginning organization is seen. (Elastic Van Gieson ×24.)

Any attempt to explain the apparent dissolution of the early fibrin clot and the rapid recanalization of the late clot under heparin influence must necessarily be speculative. Further studies are in progress in an effort to clarify these moot points. The present-day tendency has been to consider the mechanism of

coagulation and the inhibition of coagulation as a physiochemical reaction.[17] In any equation of this type, the basic factors consist of the types of materials entering into the reaction, the relative amount of the reacting components, the pH, and, finally, the time factor. Since every biochemical reaction is theoretically reversible, it is quite conceivable that with an increase in the amount of functioning circulating heparin which is allowed to act for a long period, a reversal of the thrombin + fibrinogen → fibrin equation may possibly occur.

Conceivably, a contributing factor in stimulating reparative processes such as organization and recanalization is the demonstrable effectiveness of heparin in enhancing and maintaining an elaborate collateral circulation. It is generally conceded that the phenomenon of recanalization is to a large extent predicated on physical factors. It is evident that the larger column of fluid blood, resulting from heparinization, pounding against small, recanalizing channels may well be responsible for accelerating and augmenting recanalization.

CONCLUSIONS

Heparin therapy in experimental venous thrombosis in rabbits results in the following:

1. Early clots are completely resolved.
2. Growth of the collateral venous circulation is tremendously enhanced.
3. Speed of recanalization after occlusive thrombus formation is accelerated.

REFERENCES

1. Howell, W. H.: Harvey Lectures, Series XII, 1916-17.
2. Mason, E. C.: Blood Coagulation; Production and Prevention of Experimental Thrombosis and Pulmonary Embolus, Surg., Gynec. & Obst. 39: 421, 1924.
3. Murray, D. W. G., Jaques, L. B., Perrett, T. S., and Best, C. H.: Heparin and Vascular Occlusion, Canad. M. A. J. 35: 621, 1936.
   Idem: Heparin and Thrombosis of Veins Following Injury, SURGERY 2: 163, 1937.
4. Best, C. H., Cowan, C., and MacLean, D. L.: Heparin and Formation of White Thrombi, Science 85: 338, 1937; J. Physiol. 92: 20, 1938.
5. Rabinovitch, J., and Pines, B.: Effect of Heparin on Experimentally Produced Venous Thrombosis, SURGERY 14: 669, 1943.
6. Solandt, D. Y., and Best, C. H.: Heparin and Coronary Thrombosis in Experimental Animals, Lancet 2: 130, 1938.
7. Hirsch, E., and Loewe, L.: A Method for Producing Experimental Venous Thrombosis, Proc. Soc. Exper. Biol. & Med. 63: 569, 1946.
8. Loewe, L., Rosenblatt, P., and Lederer, M.: A New Method of Administering Heparin, Proc. Soc. Exper. Biol. & Med. 50: 53, 1942.
9. Loewe, L., and Rosenblatt, P.: A New Practical Method for Subcutaneous Administration of Heparin, Preliminary Report, Am. J. M. Sc. 208: 54, 1944.
10. Loewe, L., Rosenblatt, P., and Hirsch, E.: Venous Thromboembolic Disease, J. A. M. A. 130: 386, 1946.
11. Loewe, L., and Hirsch, E.: Heparin in the Treatment of Thromboembolic Disease, J. A. M. A. 133: 1263, 1947.
12. Lange, K., Boyd, L. J., and Loewe, L.: The Functional Pathology of Frostbite and The Prevention of Gangrene in Experimental Animals and Humans, Science 102: 151, 1945.
13. Lange, K., and Loewe, L.: Subcutaneous Heparin in the Pitkin Menstruum for the Treatment of Experimental Human Frostbite, Surg., Gynec. & Obst. 82: 256, 1946.
14. Knisely, M. H., and Bloch, E. H.: Microscopic Observations of Intravascular Agglutination of Red Cells and Consequent Sludging of the Blood in Human Diseases, Anat. Rec. (Supp.) 82: 426, 1942.
15. Knisely, M. H., and Bloch, E. H.: Paper delivered at meeting of Chicago Pathological Society, Nov. 13, 1944.
16. Knisely, M. H., Eliot, T. S., and Bloch, E. H.: Sludged Blood in Traumatic Shock, Arch. Surg. 51: 220, 1945.
17. Jorpes, J. E.: Heparin in the Treatment of Thrombosis, ed. 2, London, 1946, Oxford University Press, p. 47.

EXTENSIVE BLUE NEVUS OF JADASSOHN-TIÈCHE

Report of Case

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SINCE the first blue nevus was described by Tièche,[1] there have been many reports of this lesion. According to Montgomery and Kahler[2] and Ormsby and Montgomery,[3] review of the literature revealed that the great preponderance of blue nevi are small in size, that is, they are seldom more than 15 mm. in diameter. However, more extensive blue nevi occasionally are seen. Pack and Livingston[4] reported a case in which the back of the patient was covered by a congenital blue nevus. This patient also had von Recklinghausen's disease, and a malignant melanoma subsequently developed in the interscapular area and metastasized to the lungs and brain.

We recently have observed a case of an unusually extensive blue nevus which we wish to report.

REPORT OF CASE

A white boy, aged 9 years, was first seen at the Mayo Clinic on May 1, 1946. His family and medical history, aside from the presenting complaint, was negative. His mother stated that she had noted a slightly raised, bluish skin lesion on the left side of the child's thorax when he was 4 weeks of age. The color and size of the lesion had remained relatively unchanged during his development, and no treatment had been used for the lesion. The involved area was asymptomatic.

On physical examination of the boy, the salient findings were limited to the skin of the anterior and upper part of the left side of the thorax (Fig. 1). Here there was an irregularly linear lesion, 3 to 6 cm. in width, which extended from the lower part of the sternum laterally to the left midaxillary line. The lesion was composed of multiple, firm, dark blue, round nodules, which were slightly raised above the surrounding skin. There also was a bluish discoloration of the skin in intervening small areas between the circumscribed nodules. The regional lymph nodes were not palpable.

Biopsy was not performed, but it was believed that the lesion was a vascular nevus because of its large size and general appearance. Excision of the lesion was advised because of its site and suspectibility to trauma.

On July 13, 1946, the involved skin and subcutaneous tissue were excised by a long elliptical incision extending from the sternum laterally to the left midaxillary line, beyond the edges of the lesion. It was then found that the fascia and lower portion of the pectoral muscle were deeply pigmented and, on section, the pigmentation seemed to extend through the deeper layers of muscle. The incision was not carried down to the periosteum or pleura, so we do not know how deeply the pigmentation extended. The pigmented fascia and muscle were not excised. The edges of the skin were undermined, brought together and sutured, and a Penrose drain was inserted. The lesion was healing satisfactorily when the patient was dismissed on July 26, 1946.

Pathologic Examination.—The surgical specimen consisted of skin and subcutaneous tissue, and measured 17 cm. in length, 6 cm. in width, and 2 cm. in thickness. Multiple,

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firm, dark blue nodules, which varied in size from that of a match head to that of a split pea, projected at narrow intervals from the surface of the skin throughout the extent of the lesion. On cross section, the specimen showed very dense, dark blue pigment arranged in layers. The epidermis appeared white, and beneath it the cutis was entirely blue-black in color. The fat of the subcutaneous tissues was yellow with narrow streaks of the pigment growing through it at narrow intervals down into the fascia, which also showed a mottled bluish pigmentation.

Fig. 1.—Extensive blue nevus involving the upper left portion of the anterior wall of the thorax.

Sections stained with hematoxylin and eosin showed slight hyperkeratosis and irregular, mild proliferation of the rete ridges of the epidermis. The melanin pigment in the basal cells appeared to be increased in amount in the rete ridges. The papillary portion of the cutis appeared unchanged, but in the subpapillary, middle and lower parts of the cutis, and in the subcutaneous tissues, as deep as the section extended, there were multiple, irregularly nodular collections of long, slender, spindle-shaped cells, which were concentrated about the dermal appendages of the section. These cells, in frozen section, stained dark brown with dioxyphenylalanine (dopa reagent) and were dopa-positive melanoblasts (Figs. 2, *a* and 3, *a*). Other melanin-bearing cells, which were larger, shorter, and plump, and which contained coarse granules or clumps of pigment, were seen frequently. These cells were chromatophores and were seen in the upper part of the cutis, above, as well as among, the masses of melanoblasts in the middle and lower parts of the cutis. The chromatophores, although they contained melanin, were not stained by dopa reagent and were thus dopa-negative.

All of the melanin was more distinct in sections stained with silver nitrate and hematoxylin. The black melanin pigment in the cytoplasm of the basal cells of the epidermis appeared clearly; the coarse melanin pigment in the chromatophores was pronounced, and the fine melanin granules distinctly outlined the long dendritic processes of the melanoblasts (Figs. 2, *b* and 3, *b*, and *c*). This staining method revealed melanin pigment in cells which appeared nonpigmented when stained with hematoxylin and eosin and with the dopa stain.

Ordinary pigmented nevus cells were not seen in any of the sections. These cells are oval in shape, have large vesicular nuclei, and are larger than the cells of blue nevi, which are also characterized by their long bipolar dendritic processes. Ordinary nevus cells characteristically grow in alveoli, nests, or columns, in contrast to the irregular strands and solid masses of blue nevus cells. The common nevus cell usually contains melanin pigment and gives a

positive dopa reaction when situated in the upper part of the cutis adjacent to the epidermis, but it rarely retains these properties when found deep in the cutis as in the subdermal type of nevus. The cells of the blue nevus, however, represent true dermal melanoblasts and are laden with melanin and give a positive dopa reaction.

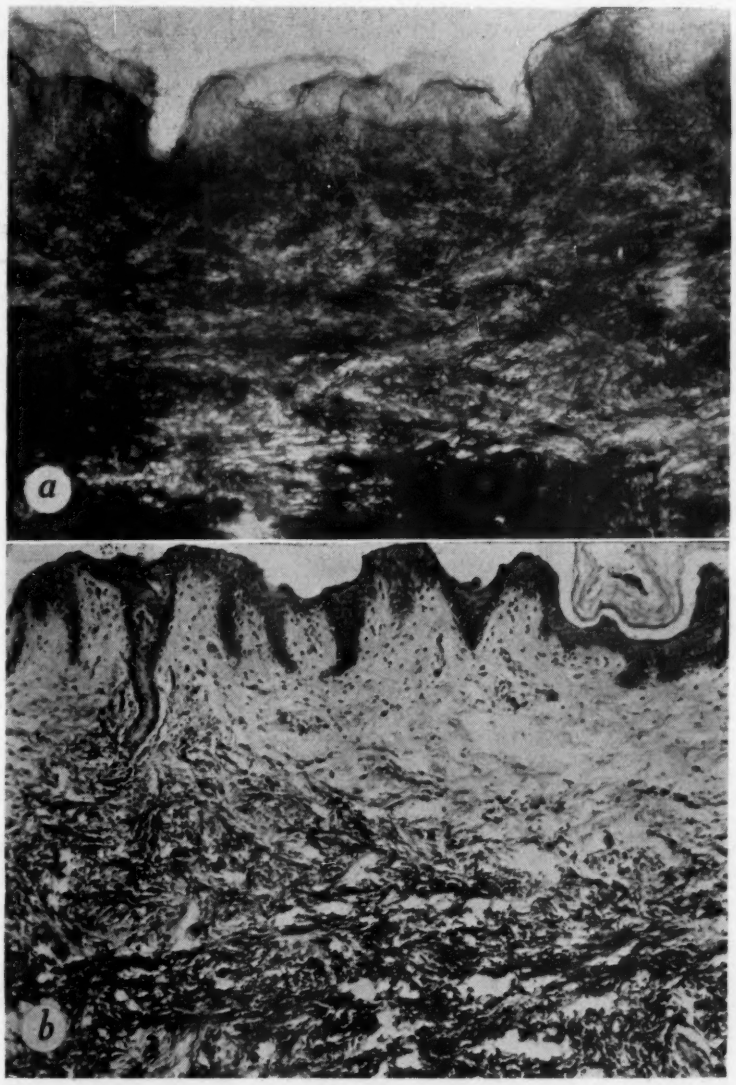

Fig. 2.—*a*, Dense black masses in the lower portion of the cutis, composed of dopa-positive melanoblasts of the blue nevus; dioxyphenylalanine (dopa) stain (×70); *b*, melanin pigment in basal cells in the tips of the rete ridges in the epidermis and also within blue nevus cells in the middle and lower cutis; silver nitrate and hematoxylin stain (×70).

SUMMARY

We have observed a case in which an extensive blue nevus of Jadassohn-Tièche occurred in a white boy, aged 9 years. The lesion was 17 cm. in length and 3 to 6 cm. in width, and extended from the lower part of the sternum laterally to the left midaxillary line. It was first noted when the child was

4 weeks of age, and remained relatively unchanged during the child's development. At operation, it was found that the blue nevus involved not only the skin and subcutaneous tissue, but the fascia and lower portion of the pectoral muscle. Only the skin and subcutaneous tissue were excised. The edges of the skin were united primarily without skin grafting. The histopathologic studies revealed that the tumor cells were all dermal melanoblasts. Ordinary nevus cells such as seen in the common mole or pigmented nevus were not found.

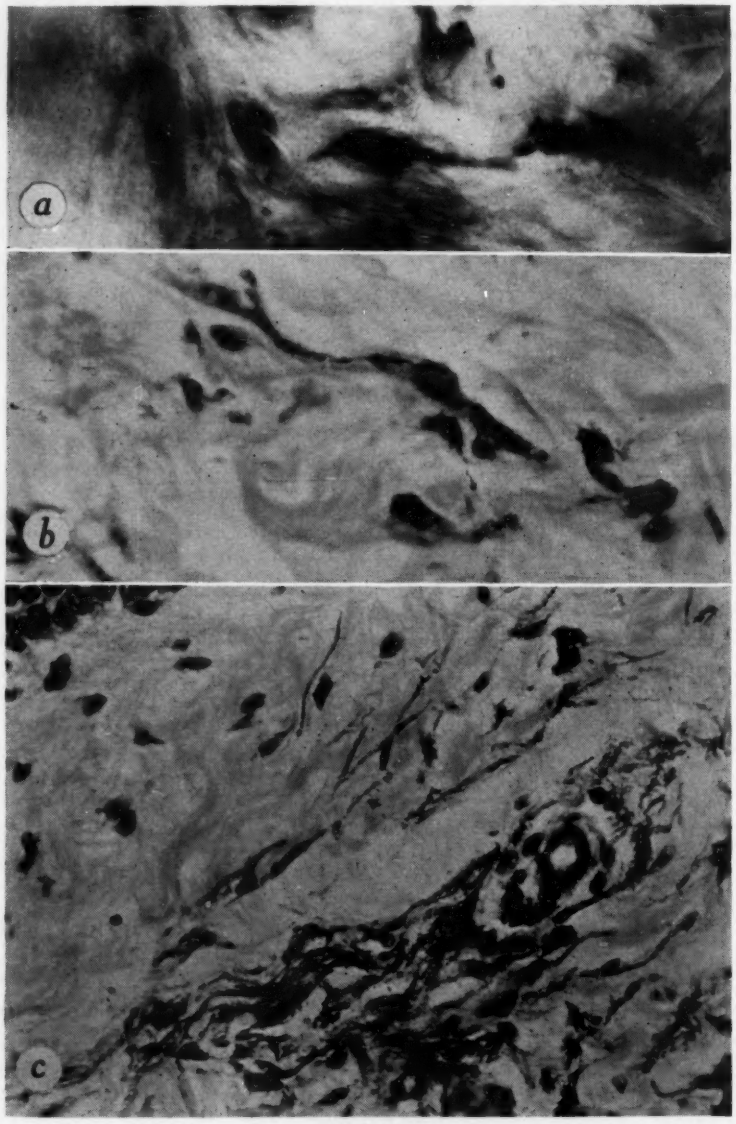

Fig. 3.—*a*, Large, bipolar, dark brown (dopa-positive) dermal melanoblast in center of section; dioxyphenylalanine stain (×435); *b*, bipolar, dendritic cell near the center of the section, its cytoplasm outlined by melanin pigment stained dark brown with silver nitrate; the cells at the lower right are short, plump chromatophores (×600); *c*, long, slender dendritic blue nevus cells about a small blood vessel in the lower part of the cutis; silver nitrate and hematoxylin stain (×400).

We are able to find reports of only ten cases of malignant change in blue nevi in the literature. Histologic studies of these lesions usually reveal the presence of another type of tumor cell in addition to the blue nevus cell either in the primary lesion or the metastatic lesions. In several instances, no histologic evidence of malignant change has been present. In only one case was there clear-cut pathologic evidence that a melanosarcoma had developed from a blue nevus. We believe, therefore, that this lesion is fundamentally benign and that no further treatment of the residual blue nevus was indicated in the case which we have reported.

REFERENCES

1. Tièche, Max: Ueber benigne Melanome (''Chromatophorome'') der Haut—''blaue Naevi,'' Virchows Arch. f. path. Anat. **186**: 212-229, 1906.
2. Montgomery, Hamilton, and Kahler, J. E.: The Blue Nevus (Jadassohn-Tièche): Its Distinction From Ordinary Moles and Malignant Melanomas, Am. J. Cancer **36**: 527-539, 1939.
3. Ormsby, O. S., and Montgomery, Hamilton: Diseases of the Skin, ed. 6, Philadelphia, 1943, Lea & Febiger, p. 706.
4. Pack, G. T., and Livingston, E. M.: Treatment of Cancer and Allied Diseases, by One Hundred and Forty-Seven International Authors, New York, 1940, Paul B. Hoeber, Inc., vol. 3, p. 2077.

BENIGN INTESTINAL TUMORS OF VASCULAR ORIGIN

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HISTORICAL

ROKITANSKY (1861), in discussing vascular tumors of the intestine, stated that they were of the rarest occurrence, and when found consisted of telangiectasis of the intestinal mucous membrane. The first report of angiomas of the intestine was by Gascoyen (1860). Thirty-eight years later Longuet (1898) called attention to the rarity of the condition and, citing three instances, questioned the authenticity of one. These three examples were discussed by Heurtaux (1899), who also commented on their rarity. MacCallum (1906) reported a case from the pathologic laboratory of Johns Hopkins Hospital, and reviewed five others. Dewis (1906), writing on benign tumors of the intestine, commented on the rarity of intestinal angiomas. Following a review of the literature, King (1917) found records of only three, and these, he maintained, were incomplete.

Helvestine (1923) grouped fourteen examples from the literature and added one which he found at necropsy. Brown (1924), after a careful review of the literature summarized nineteen case reports of the vascular tumors in question (exclusive of the stomach), and added one of his own. These included all varieties from capillary nevi to cavernous angiomas. Bancroft (1931) listed eight additional case reports, and reported one of his own. To this balance sheet we add nine more, including one of our own, to bring the total to thirty-eight.

CASE REPORT

J. C., a white man, aged 58 years, first consulted us Oct. 17, 1938, complaining of melena, belching, and abdominal distention.

Family history indicated no bleeding tendency in any of its members, and was otherwise completely irrelevant. The patient had been treated for gastric ulcer ten years previously.

The illness for which he consulted us began one week previously when he noticed bright red blood in stools. There was no pain on defecation, or constipation, the patient having two bowel movements daily. Some abdominal distention and belching were present. There was no loss of weight; appetite was good.

Physical examination showed a chronically ill man in the late fifties, presenting marked pallor of the skin. Heart and lungs were unaffected. Blood pressure was 145/90. Abdominal examination revealed no abnormalities or tenderness, except for several nevi scattered over abdominal wall. Nasal mucosa was intact and normal. Rectal examination was negative.

Sigmoidoscopy disclosed no evidence of neoplasm or other pathologic changes. Barium enema showed several diverticula in the descending colon and sigmoid. Complete gastrointestinal roentgenologic examination showed no abnormal conditions.

Urinalysis revealed specific gravity, 1.026; albumin, negative; sugar, negative; microscopic 2 to 3 white blood cells per high power field. Blood count was as follows: Hemoglobin, 57 per cent (8.3 Gm. per 100 c.c.); red blood cells, 2,680,000; white blood

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cells, 6,250; color index, 1.03; polymorphonuclears, 62 per cent; lymphocytes, 30 per cent; mononuclears, 6 per cent. Blood Wassermann was negative.

Blood chemistry and gastric analysis were normal.

The patient was under observation until Oct. 18, 1941, when hospitalization became urgent because of severe intestinal hemorrhage and diarrhea. He was extremely pale and felt severely asthenic. Hemoglobin was 40 per cent. Immediate transfusion of 500 c.c. of citrated blood was performed. This was the first of many transfusions required (104 in all) during our years of observing and treating this patient.

On Nov. 19, 1941, an exploratory laparotomy was performed (J. A. L.). The liver and stomach disclosed no visible abnormalities. During the course of examination of the small intestine and colon a few small dark purplish, pinhead- to matchhead-sized spots were observed by transmitted light shining through the serosa. These were present throughout the entire length of the bowel. A solitary cyst of the lower pole of the left kidney was palpated and removed through a left lumbar incision. Following the operation many transfusions were necessary before he was discharged (Dec. 31, 1941).

A course of deep roentgen therapy was given with the hope of favorably influencing what we believed to be intestinal nevi similar to those seen on the abdominal skin. However, intermittent intestinal hemorrhages occurred, requiring further and more frequent blood replacement.

On Feb. 14, 1946, following sigmoidoscopy and a barium enema roentgenologic study, we believed that another exploration was advisable with the hope of finding a bleeding polyp or angioma which had possibly escaped previous detection. Immediately after this exploration the patient suffered a profuse intestinal hemorrhage, with hemoglobin dropping to 20 per cent. After repeated transfusions and proper presurgical intestinal preparation, a laparotomy was performed (March 14, 1946, J. A. L.). The entire gastrointestinal tract was again subjected to a minute and critical examination, with the same result as at the previous operation. Despite the presence of a few purplish spots in the small intestine, we conjectured that most of the pathologic change was within the colon, and decided to perform a colectomy as a lifesaving measure. Due to the patient's poor physical condition, we deemed it advisable to carry out the operation in multiple stages. The ileum was, therefore, completely transected about twelve inches from the ileocecal valve, and the proximal end implanted end-to-side into the rectosigmoid directly above the peritoneal reflexion.

Twelve days later the colon was removed up to the splenic flexure, the distal end being left in the wound as a mucous fistula, when the operation had to be discontinued because of the patient's poor physical condition. A transfusion of 500 c.c. of blood was administered during the surgical procedure. At the conclusion of the laparotomy, a nevus was removed for histologic examination from the skin of the abdominal wall.

Following discharge from the hospital the patient remained well except for an occasional drop of blood in the stool. On Sept. 10, 1946, the remainder of the descending colon up to the anastomosis was removed. Convalescence was uneventful except for one episode of brisk intestinal bleeding which required three transfusions. He was discharged from the hospital Sept. 26, 1946. There has been no bleeding to date.

Pathology Reports.—Specimen 1, cyst of left kidney, was removed at the first operation. Macroscopic examination showed the specimen to consist of a mass of tissue measuring 5 by 4 cm., which mainly composed the wall of a cyst. The wall was thin, fibrotic, and transparent. A small amount of fat tissue was adherent to it. The intimal lining was smooth. Renal parenchyma tissue was not grossly recognizable within the specimen. At one site there was a fibrotic placque which contained a pinhead- sized cyst.

Microscopic examination showed that the wall of the cyst was lined by a zone of dense collagenous fibrous tissue. Within parts of the latter there were atrophic and dilated tubules, in the interstices of which round-cell infiltration was present. Atrophic and intact glomeruli were also present. Another small cyst was observed in the wall, which was lined by regular cuboidal cells.

Diagnosis was fibrotic simple cyst of the kidney with atrophy of adjacent parenchyma.

Specimen 2 was removed at the third operation. Macroscopic examination revealed: (1) The specimen consisted of an ileocolectomy specimen consisting of 7.5 cm. of ileum, and the ascending and transverse colon. The mucosa showed no unusual features. Within the cecum at a distance of 15 cm. from the ileocecal valve there was a pea-sized polyp with a hyperemic surface which rested on top of a mucosal fold. There was no induration of the submucosa. This polyp was not hemorrhagic. Throughout the colon there were several small hyperemic, bluish, localized ecchymotic spots, the largest of which was the size of a split pea. These were considered cavernous angiomas. They were limited to the mucosa and submucosa, showed no ulceration, and were situated at 17, 40, and 65 cm. from the ileocecal valve. The remainder of the colonic mucosa was smooth and pale. No lymph node enlargements were present.

Fig. 1.—Microphotograph of section through skin. Epidermis is intact. Within the subcuticular stroma are several congested blood vessels with dilated lumina lined by flat endothelium with regular nuclei (×135 magnification).

(2) A pea-sized fragment of skin tissue removed from the anterior abdominal wall contained a raised bluish superficial smooth area, and presented the characteristics of a capillary nevus of the skin (Fig. 1).

Microscopic examination revealed: (1) Sections through the cecal polyp showed that the polyp consisted of glandular mucosal tissue which was in continuity at the base with the adjacent mucosa. The glands and surface epithelium were regular and lined by columnar cells with regular nuclei. The stroma was delicate and contained numerous congested

blood vessels of capillary variety. The stroma also contained round, plasma, and some red blood, cells. The base of the polyp and the subjacent submucosa contained several larger congested blood vessels, including those with smooth muscle coats. The adjacent cecal wall was free from inflammatory changes.

(2) Sections through the lesions at 17 cm., 40 cm., and 65 cm. showed that the histologic characteristics of these lesions were similar. The mucosa was intact. The stroma contained round cells, plasma cells, and some congested capillaries. Within the submucosa there were numerous congested blood vessels, some of which were dilated. They were all lined by regular flat endothelium. Some had a distinct muscular coat; others were devoid of the muscular coat. The stroma in these areas contained occasional round cells, but showed no distinct interstitial hemorrhage or blood pigment deposits. There were no inflammatory changes around these blood vessels. These lesions were definitely hemangiomatous in character (Fig. 2).

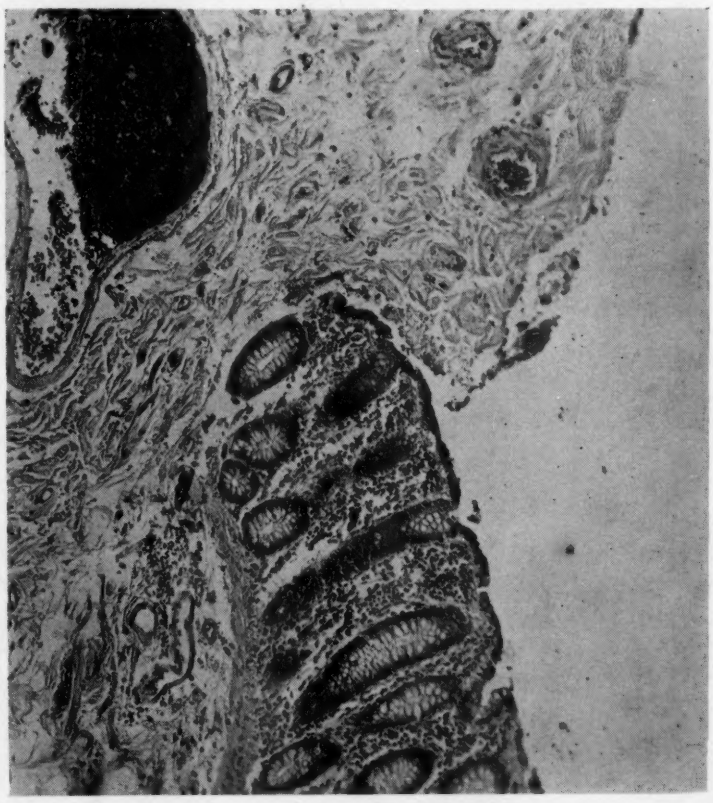

Fig. 2.—Microphotograph of section through lesion at 17 cm. Mucosa is intact. Its stroma contains round and plasma cells and congested capillaries. Within the submucosa are numerous congested, dilated blood vessels lined by regular flat endothelium (telangiectasia) (×135 magnification).

Specimen 3 was removed at the fourth operation. Macroscopic examination showed that this consisted of a resected portion of large intestine, comprising the splenic flexure, descending colon, and sigmoid colon. It measured 45 cm. in length by 5 cm. in width. At a distance of 24 cm. from the distal end there was a pedunculated polyp with its ulcerated and hemorrhagic tip about the size of a cherry. It consisted of brownish and grayish-pink cellular tissue and was attached to the mucosa by a 2 cm. long, smooth, fibrous stalk. The mucosa contained a split-pea sized, smooth, bluish structure (capillary nevus or angioma) at a distance of 2 cm. from the base of the polyp (Fig. 3). There were several scattered diverticula in this portion of the gut.

Microscopic examination revealed the following: (1) Section through the polyp showed that it was composed of regular mucosal glands lined by mucinous columnar cells with regular nuclei. No definite ulceration was found on its surface, but a single layer of regular columnar epithelium separated the lumen from the hemorrhagic areas within the subjacent stroma. The latter showed similar hemorrhagic foci and hyperemia within the deeper portion of the stroma. Brown pigment was present within these areas, some of which represented formalin artefacts; others consisted of brown pigment within histiocytes. The stalk stroma was hyperemic and hemorrhagic (Fig. 4).

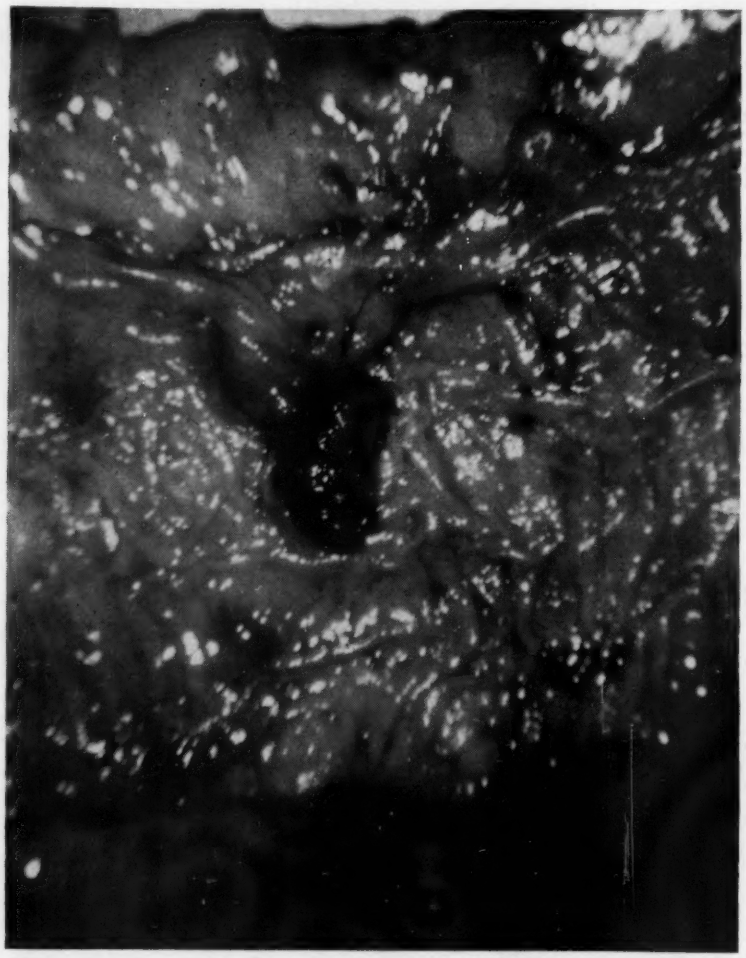

Fig. 3.—Photograph showing pedunculated polyp with capillary nevus at 2 cm. from its base.

(2) Sections at random from adjacent mucosa showed the mucosa to be intact. The submucosa contained several congested venules and capillaries. There was no interstitial hemorrhage in the adjacent stroma.

(3) Sections through bluish lesions (cavernous angiomas) revealed that the overlying mucosa was intact and showed no ulceration. The subjacent stroma showed prominent interstitial hemorrhages without leucocytic or round-cell infiltration. It contained several prominent vascular spaces lined by a single layer of endothelium, and was devoid of a muscular coat. There were also several congested blood vessels. Some were venules and con-

Fig. 4.

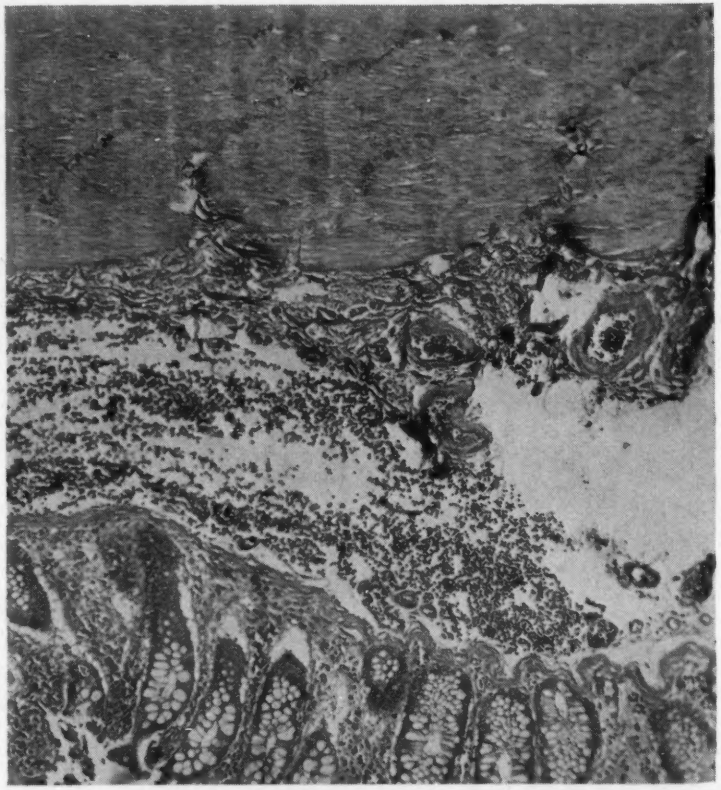

Fig. 5.

Fig. 4.—Microphotograph of section through polyp which is composed of regular mucosal glands lined by regular mucinous columnar cells and regular nuclei (×18 magnification).

Fig. 5.—Microphotograph of section through the blue lesion. Overlying mucosa is intact. The subjacent stroma shows interstitial hemorrhage without leucocytic or round-cell infiltration, and contains several vascular spaces lined by a single layer of endothelium (×135 magnification).

TABLE

AUTHOR	DATE	SEX	AGE	OUTSTANDING SYMPTOMS	DURATION OF SYMPTOMS
Gascoyen	1860	M	44	None	
Laboulbene	1872	M	64	Repeated hemorrhage from bowel and vomiting of black blood	About 2 mo.
Boyer	1877	M	62	None	
Paci	1882	F	? Young	Intestinal obstruction, passed tumor	Not stated
Barker	1883	M	43	Diarrhea and hemorrhage from bowel; mucous membrane of rectum blue and ulcerated	Since boyhood
Marsh	1883	F	10	Continuous and sometimes severe intestinal hemorrhages	8 yr.
Delbet	1899	F	21	Emaciation and symptoms of intestinal obstruction	Long history of intestinal disturbance
Nicoll	1899	F	23	Pain, vomiting, obstipation	About 2 weeks
Hektoen	1900	M	48	None	
MacCallum	1906	M	54	Digestive disturbances	Many months
Benneke	1906	M	52	None	
Ohkubo	1907	F	62	None	
Ohkubo	1907	M	79	None	
Tuffier	1913	M	37	Intestinal hemorrhage and anemia	30 yr.
Hartmann	1913	F	22	Rectal hemorrhages	Not stated
Kausch	1916	M	17	Bloody stools, hemorrhage, anemia	16 yr.
Dujarier and Topous Khan	1920	M	?	Rectal bleeding, anemia, loss of weight	3 yr.

I

CHARACTER OF LESION	LOCATION OF LESION	TREATMENT	RESULT	NECROPSY
Nevus originating in submucosa and projecting into lumen of intestine	Small bowel	None	Suffocation from nevus of parotid gland	Numerous nevi found over entire body
Elevated tumor size of almond in submucosa of duodenum above papilla of Vater, consisting of dilated capillary spaces; mucosa intact	Duodenum	None	Died of hemorrhage	Lesion found at autopsy
Small rounded dark spots visible when gut was held up to light, occupying about 6 ft. of free margin of lower jejunum and upper ileum, attached to arterial arcades, situated in submucosa	Lower jejunum and upper ileum	None	Died of pneumonia	Lesion found at autopsy
Cavernous tumor presenting hemorrhage in its substance, and composed of cavernous sinuses in center	Not known	None	Recovery; tumor passed spontaneously from rectum	
Nevoid growth on walls of rectum, with ulcerations of mucosa	Rectum	Injection with tincture of ferric. Perchloride	Stricture of rectum; died of anemia	
Speculum examination showed a nevoid growth completely surrounding rectum	Rectum	Paquelin cautery	Relief, but no cure	
Growth surrounded intestine like a ferrule and protruded 3 cm. above surface; angioma	Small intestine (submucosa and muscularis)	Resection	Death after operation	
Tumor size of a pigeon's egg in small intestine, causing intussusception; tumor thin walled, spaces filled with coagulated blood; typical nevoid tumor	Small intestine (submucosa)	Resection	Recovery	
Many enlarged veins showing globular dilatations	Upper third small intestine (submucosa)	None	Died of aortitis and mitral endocarditis	Yes
Small firm purplish nodules throughout small intestine best seen by transmitted light; histologically they were vascular tumors of cavernous structure	Small intestine (submucosa invading muscularis)	None	Died; arteriosclerosis; bronchopneumonia	Yes
Cavernous phlebectases appearing as many small brownish red masses	Entire gut (submucosa)	None	Died of tuberculous meningitis	Yes
Many varices	Jejunum (submucosa)	None	Died of pneumonia	Yes
Cavernous angioma	Small intestine (submucosa)	None	Died of pneumonia	Yes
Sigmoidoscopy: a small purplish mass size of pea 22 cm. from anus, with ulcerated mucosa (angiomas)	Sigmoid (submucosa)	Cauterization followed by laparotomy	Died	Yes
Small angioma	Rectosigmoid	Fulguration	Cured	
Cavernous angioma involving entire colon	Entire colon	Operation—colostomy, 5-stage colectomy	Improved	
Numerous cavernous angiomas	Sigmoid	Exploratory laparotomy	Not stated	

TABLE

AUTHOR	DATE	SEX	AGE	OUTSTANDING SYMPTOMS	DURATION OF SYMPTOMS
Judd and Rankin	1922	F	22	Nausea and epigastric distress	Years
Hume	1922	M	48	Repeated rectal hemorrhages	10 yr.
Helvestine	1923	F	72	None	
Bland, Mashke and Karsner	1923	F	2 mo.	Persistent vomiting	4 days
Hennig and Schütt	1923	M	23	Rectal hemorrhage, melena	16 yr.
Bensaude and Antoine	1923	F	21	Rectal hemorrhage, colic, anemia, cachexia	6 weeks after birth
Bensaude and Antoine	1923	M	48	Profuse hemorrhage from rectum	37 yr.
Brown	1924	F	12	Pain in lower abdomen, stercoraceous vomiting, obstipation	Sudden onset
Reichel and Staemmler	1924	M	78	Not stated	Not stated
Buie and Swan	1929	F	47	Symptoms of gall bladder disease	Not stated
Buie and Swan	1929	F	48	Passage of small amounts of blood from rectum; acute intestinal obstruction 1 mo.	4 mo.
McClure and Ellis	1930	F	30	Anemia, tarry stools, constipation, blood tumors on skin	10 yr.
Bancroft	1931	M	17	Rectal bleeding, diarrhea, constipation, anemia	Since age of 15 mo.

tained a smooth muscle layer; others were arterioles and contained a broader smooth muscular coat. The subjacent muscular wall of intestine showed no unusual features and was devoid of interstitial hemorrhage (Fig. 5).

(4) Section through the sigmoid showed a diverticulum lined by a regular mucosa similar to adjacent mucosa. The diverticulum had a smooth muscle coat and was free of inflammatory changes.

I (CONT'D)

CHARACTER OF LESION	LOCATION OF LESION	TREATMENT	RESULT	NECROPSY
Rounded tumor filling duodenum, consisting of a mesh of capillaries and a few dilated sinuses supported by highly cellular stroma	Duodenal side of pylorus	Operation—tumor enucleated	Recovery	
Hemangioma	Rectum	Transfusion and packing of rectum with kaolin	Death from hemorrhage	Not stated
Pedunculated encapsulated tumor on outer surface of jejunum (cavernous angioma)	Jejunum 27 cm. from pylorus	Not stated	Died of pneumonia	Yes
Capillary hemangioma in mesentery and including all layers of intestinal wall except mucosa	Ileum 30 cm. from ileocecal valve	None	Died	Yes
Inoperable diffuse angioma of entire colon	Entire colon	Not stated	Death	Not stated
Diffuse angioma of rectum and sigmoid	Rectum and sigmoid	Transverse colostomy and deep x-ray treatment	Improved	
Diffuse angioma of rectum	Rectum	Opium, bed rest, calcium chloride injections	Death from hemorrhage	No
Annular tumor 5 in. in length, involving entire circumference of intestine, showing dilated blood spaces (cavernous angioma)	Small intestine	Resection	Death	No
Cavernous hemangioma	Entire colon	Not stated	Death	Yes
Diffuse venous hemangioma	Appendix and cecum	Cholecystectomy and exploration	Not stated	
Annular cavernous hemangioma of colon	Colon	Operation for intestinal obstruction, cecostomy	Not stated	
Cavernous hemangioma of liver; multiple hemangiomas of stomach, duodenum, and jejunum	Stomach, duodenum, liver, and jejunum	Blood transfusions and laparotomy	Died 4 mo. later	No
Congenital angioma	Rectum	Colostomy, ligation superior hemorrhoidal vein and injection of 10 c.c. of 40% solution of sodium salicylate	Cure (follow-up after 15 mo.)	

Diagnosis was: (1) resected large intestine, (2) benign hemorrhagic pedunculated adenomatous polyp of colon, (3) diverticulosis of colon without inflammation, and (4) hemorrhagic submucosal telangiectasis of colon (cavernous angioma).

We concluded that the severe episode of intestinal bleeding during the phase of convalescence following the last operation was due to activation of nevi in the small intestine.

TABLE

AUTHOR	DATE	SEX	AGE	OUTSTANDING SYMPTOMS	DURATION OF SYMPTOMS
Bensaude, Hillemand, and Genestoux	1935	F	44	Bloody diarrhea, pallor	Few months
Ackerman	1937	M	70	Not stated	Not stated
Ackerman	1937	M	64	No gastrointestinal symptoms	
Ackerman	1937	M	81	No gastrointestinal symptoms	
Rainey	1938	M	?	Rectal bleeding and diarrhea entire life	Entire life
Amundsen	1938	M	65	None	
Sawyer	1939	M	55	Pain lower abdomen, constipation, blood in stool, loss of weight	3½ mo.
Lazarus and Marks	1947	M	58	Profuse rectal hemorrhages	1 week

ANALYSIS OF CASE REPORTS

Age and Sex.—The youngest example was that of an infant 2 months of age, and the oldest 81 years. There were twenty-three reports of tumor in men, and fifteen in women.

Symptoms.—In 9, symptoms referable to the intestinal tract were absent, and in 3 others were not recorded. In the remaining 26, bleeding was a constant symptom in 18 (69.2 per cent); and of these, 6 occurred in women and 12 in men. Intestinal obstruction was noted 5 times, and all were in women. The duration of symptoms varied from sudden onset to 48 years. In 7 patients symptoms persisted less than 1 year, and in 15 more than 1 year, while the duration of symptoms was not indicated in 16.

Location of Lesion.—The site of the tumor was not mentioned in 1 report. The stomach, duodenum, jejunum, and liver were involved in 1; duodenum in 1; small intestine in 14; small intestine and sigmoid in 1; colon in 8; rectum in 5; rectum and sigmoid in 1; rectosigmoid in 1; sigmoid in 2; and entire gut in 3.

I (CONT'D)

CHARACTER OF LESION	LOCATION OF LESION	TREATMENT	RESULT	NECROPSY
Cavernous angioma	Small intestine and sigmoid	Exploratory laparotomy	Death	Yes; a number of small subserous ecchymotic spots in small intestine; also a few in sigmoid
Hemangioma	Jejunum	Not stated	Death	Yes; a reddish blue lesion in jejunum in submucosa showing vascular spaces with endothelial lining
Hemangioma	Ileum and jejunum	Not stated	Death	Yes; 6 raised reddish lesions with bluish tint in ileum and jejunum in submucosa; Micro.: endothelial lined spaces filled with blood
Elevated dusky violet nodules studding surface of small and large bowel, submucous and subserous	Entire intestinal tract, hands, and lip	Not stated	Death due to retroperitoneal perforation and hemorrhage	Yes
Cavernous angiomas	Entire colon	None	Death	Yes
Nevi (cavernous)	Entire intestinal tract	Not stated	Death	Yes
Capillary hemangioma	Decending colon	Mikulicz resection	Recovery	
Small capillary angiomas of colon	Colon	Colectomy	Improvement	

Character of Tumor.—The lesion was reported histologically as a nevus or nevoid in character in 6 patients. There were 11 instances where the tumor was designated angioma, and in 11 cavernous angioma. In 5 it was called capillary hemangioma, in 2 varicosities, and in 1 the condition was noted as cavernous phlebectasis. In 4 patients, including the authors', the tumors appeared as small rounded, dark spots when the involved segment of gut was held up to transmitted light. The presence of skin nevi was reported 3 times (Gascoyen, McClure and Ellis, Lazarus and Marks).

Brown categorized the tumors as follows:

1. Multiple tumors arranged along vascular arcades of the bowel, appearing as small red nodules situated in the submucosa, attached to arteries or veins, and best seen by transmitted light. Histologically these lesions were described as nevi or capillary angiomas.

2. Submucous tumors growing into the lumen of the bowel, a few of which produce ulcerations of the mucosa.

3. Submucous tumors sufficiently large to occlude the lumen of the bowel, and to cause intussusception with or without intestinal obstruction.

4. Diffuse tumors arising in the submucosa and completely encircling and constricting the bowel to cause intestinal obstruction.

Lesions Found Only at Autopsy.—In fifteen patients the tumor was discovered at necropsy, and in the majority symptoms referable to the intestine were entirely lacking.

Treatment.—Surgery was done. Resection of the tumor was performed in four patients, colectomy in two, and colostomy in two. In the latter, one was followed by deep roentgen therapy, and the other was injected with sodium salicylate.

Local therapy was administered in five patients. Three were treated by cauterization, one with transfusions and packing, and one with bed rest, morphia, and calcium chloride injections.

Results.—Five patients succumbed after surgery; 5 died of hemorrhage without surgical intervention. One patient (Paci) passed the tumor spontaneously and recovered. In 4 instances relief was reported—1 treated with cauterization (Marsh); 2 following colectomy (Kausch, Lazarus and Marks); and 1 following colectomy and deep roentgen therapy. Recovery of 4 patients was reported—2 following resection (Nicoll; Judd and Rankin); 1 following cauterization (Hartmann); and 1 after ligation of the hemorrhoidal vein followed by injection (Bancroft).

SUMMARY AND CONCLUSIONS

Benign tumors of vascular origin arising within the intestinal tract are rare. This report deals with 38 examples collected from the literature, including one by the authors. Although symptoms were lacking in 9 of the 38 patients profuse intestinal bleeding was the main symptom in the majority. The duration of symptoms varied from sudden onset to 48 years. The majority of tumors occurred solely in the small intestine, and 8 in the colon alone. Lesions have been designated as nevi, 6; angioma, 11; cavernous angioma, 11; and capillary hemangioma, 5. The presence of associated skin nevi was reported on 3 occasions.

Tumors may occur singly or multiply. The most satisfactory results were obtained when the tumors were single, and amenable to resection. The prognosis for multiple tumors is poor. The condition should be kept in mind in all instances of severe intestinal bleeding where an obvious lesion cannot be clinically ascertained.

An unusual case of severe intestinal bleeding due to multiple intestinal capillary angiomas, associated with skin nevi, is herewith described.

REFERENCES

Ackerman, L. V.: Am. J. Cancer **30**: 753, 1937.
Amundsen, P.: Tract, Nord. med. **99**: 278, 1938.
Bancroft, F. W.: Tr. Am. S. A. **49**: 458, 1931.
Barker, E. T.: Lancet **1**: 637, 1883.

Benneke, H.: Arch. f. path. Anat., Berl. **184:** 171, 1906.
Bensaude, R., and Antoine, E.: Arch. d. mal. de l'app. digestif. **13:** 1, 1923.
Bensaude, R., Hillemand, P., and Genestoux, J. M.: Arch. d. mal. de l'app. digestif. **25:** 95, 1935.
Bland, M. E., Mashke, A. S., and Karsner, H. T.: Am. J. Dis. Child. **26:** 379, 1923.
Boyer: Bull. Soc. anat. de Par. **2:** 238, 1877.
Brown, A. J.: Surg., Gynec. & Obst. **39:** 191, 1924.
Buie, L. A., and Swan, T.: S. Clin. North America **9:** 893, 1929.
Delbet: Par., Lecons de clin. chir., 1899.
Dewis: Boston M. & S. J. **155:** 427, 1906.
Dujarier, C., and Topous Khan: Bull. et mém. Soc. anat. de Par. **90:** 33, 1920.
Gascoyen: Tr. Path. Soc. Lond. **11:** 267, 1860.
Hartmann: Bull. et mém. Soc. Anat. de Par. **38:** 274, 1913.
Hektoen, L.: Tr. Chicago Path. Soc. **3:** 192, 1900.
Helvestine, F., Jr.: Ann. Surg. **78:** 42, 1923.
Hennig and Schütt: Mitt. a. d. Grenzgeb. d. Med. u. Chir. **36:** 235, 1923.
Heurtaux: Arch. prov. de chir., **8:** 701, 1899.
Hume, G. O.: Guy's Hosp. Gaz. **36:** 360, 1922.
Judd, E. S., and Rankin, F. W.: Ann. Surg. **76:** 28, 1922.
Kausch, W.: Verhandl. d. deutsch. Geselisch. f. Chir. **43:** 243, 1914.
Kausch, W.: Mitt. a. d. Grenzgeb. d. Med. u. Chir. **29:** 399, 1916.
King: Surg. Gynec. & Obst. **25:** 54, 1917.
Laboulbene: Bull. Acad. d. méd., Par. 25, 1872.
Landois, F.: Beitr. z. klin. Chir. **133:** 685, 1925.
Longuet: Progrès méd. **8:** 137, 1898.
MacCallum, W. G.: Johns Hopkins Hosp. Bull., 17, 1906.
McClure, R. D., and Ellis, S. W.: Am. J. Surg. **10:** 241, 1930.
Marsh: Lancet **1:** 637, 1883.
Nicoll, J. H.: Brit. M. J. **1:** 842, 1899.
Ohkubo: München. med. Wchnschr. **54:** 2189, 1907.
Paci: Sperimentale, 149, 1882.
Rainey, W. R.: . Tr. Am. Proct. Soc. **39:** 111, 1938.
Reichel, P., and Staemmler, U.: Die Neuhldungen dens Darmes; Stuttgart, 1924, Ferdinand Enke (Neue deutsch Chir. **330:** Haemangioma 282-284).
Roedelius, E.: Virchows Arch. f. path. Anat. **246:** 420, 1923.
Rokitansky, C.: Lehrbuch der pathologischen Anatomie, ed. 3, Vienna, 1861, Wilhelm Baumuller.
Sawyer, C. F.: Arch. Surg. **39:** 987-991, 1939.
Shillito, N.: Pennsylvania M. J. **24:** 421, 1921.
Tuffier: Bull. et mém. Soc. de chir. de Par. **38:** 268, 1913.
Winternitz and Boggs: Johns Hopkins Hosp. Bull. **21:** 203, 1910.

WAR INJURIES OF THE CHEST

A Report of a Series of 678 Cases

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AFTER each war, review of the surgical management of its multitudinous casualties has constantly yielded much to be applied in the next of the inevitable succeeding wars. Numerous reports (Sanger,[1] Snyder,[2] and Welch and Tuhy[3]) have demonstrated the much lower mortality of thoracic wounds in the recent great war as compared to World War I of 1914 to 1918. Nevertheless, it seems worth while to report the additional experience of a relatively large group of cases which were handled in a forward semimobile evacuation hospital throughout a period of eight campaigns, especially as the early management largely determines the eventual outcome. Beginning in the North African Invasion and continuing throughout the Tunisian Campaign only the precepts of previous wars were available to us as a guide. By constant application of the newer chemotherapeutic advances, and an appreciation relatively early that the goal of early treatment was a rapid re-establishment of normal circulatory and respiratory physiology, and prompt re-expansion of the lung, gratifying results were evident relatively early in our experience. Air replacement after aspiration of hemothorax was never used and greater amounts were constantly aspirated. Thus, as we progressed through the Sicilian Campaign, Normandy Invasion, Northern France, Rhineland, Ardennes, and Central European Campaigns, therapeutic approach to these cases became more positive. The first 133 patients were treated in the Mediterranean Theater; the remainder cover the period from D-Day plus 5 to the end of the war in Europe. The causes of failure in treatment as represented by fatality were constantly examined and reported and will be discussed under the different types of wounds.

PREOPERATIVE MANAGEMENT

The patients with thoracic wounds were early segregated and this allowed standardization and efficiency of management, especially postoperatively. Unless obviously suffering little or no effect from their wounds, those patients with wounds of the chest were sent to the shock ward for preoperative preparation. Here all facilities for rapid replacement of blood loss, oxygen administration, reinforcement or change of dressing, or thoracentesis were immediately available. Here adequate complete examination could be performed, so often impossible under the overwhelming crowding of the receiving office under the massive influx of casualties during heavy engagements.

On admission to the shock wards, all patients received oxygen through a B.L.B. mask and plasma therapy was instituted. Detailed examination of the patient was then carried out, with emphasis being placed on the examination of

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the wound, as it was not uncommon to find patients with sucking wounds of the chest who, either because of inadequate dressing or derangement of adequate dressing in transit, arrived at the hospital with the wounds still sucking. Adequate dressing closure was accomplished by the use of large strips of petrolatum gauze and a firmly applied gauze pad. Packing was not practiced and is strongly condemned. No sudden deaths occurred in this series during any changes of dressing. Patients who were labeled open pneumothorax and had adequate occlusive dressings were not disturbed prior to surgical closure. Physical examination of the chest was done in all cases, although at times hastily. It has been the experience of this service that with proper care and the help of the ward nurse, this examination may be conducted without undue strain on the patient and is of immeasurable value to the attending surgeon. Tetanus toxoid was given all patients who had not previously received it, a most infrequent occurrence. Morphine was used where indicated, but never in doses greater than ¼ grain. Codeine was never used. All patients were made to lie on the affected side in a semirecumbent position. Shock was combated by the use of large quantities (1000 to 3000 c.c.) of plasma and whole blood. It must be emphasized that in patients with serious chest wounds, whole blood transfusions are imperative. Plasma per se is inadequate in stabilizing patients who have had serious blood loss. Quantities of whole blood up to 2500 c.c. were often administered with gratifying results. During the African and Sicilian Campaigns, large quantities of fresh whole blood were made available through the maintenance of a "living blood bank," which consisted of twenty Corps service troops divided among the four blood types, each man being replaced by a new one as soon as he had donated blood. This service was maintained twenty-four hours a day, every day, during the bloodiest phases of the Tunisian Campaign. No patient in shock, unless actively bleeding, was operated upon until he was well stabilized.

All new patients were examined between operation and scheduled for surgery in the order of urgency. On several occasions, a valvular tension pneumothorax was decompressed on the spot because of the patient's critical condition.

All patients with few exceptions had an anteroposterior and lateral film of the chest, fluoroscopy, and a flat plate of the abdomen taken on the way to the operating tent, and wet film readings were done during the skin preparation phase of the operation.

The less seriously wounded patients were examined as soon after admission as possible, a tentative diagnosis was made, and the following routine orders instituted: (1) have patient lie on affected side or flat on back, never on good side; (2) check temperature, pulse, respiration, and blood pressure every two hours, (3) give no codeine or barbiturates; (4) use morphine sparingly and only on order; (5) encourage cough and expectoration; (6) treat dehydration by intravenous glucose, saline solution, and plasma; (7) get x-ray views of chest, anteroposterior, and lateral; (8) watch carefully for any changes, especially in respiratory rate, pulse rate, or development of cyanosis, and report them immediately.

All necessary operative procedures in this group were performed in order of priority of emergency. In this group, simple débridement and thoracentesis were the two most common procedures, which in themselves require little preparation.

ANESTHESIA

The importance of the proper choice of anesthesia is well recognized, and in operations upon those with serious wounds of the thorax, the anesthetist and surgeon are more often confronted with poor-risk patients since many are suffering from varying degrees of shock as well as an abnormal or altered respiratory exchange.

Anesthesia used in all cases in this series was either one of two forms. Endotracheal closed anesthesia with positive pressure technique, using nitrous oxide, oxygen, and ether, was employed in all open cases, including exploratory thoracotomy and the débridement and closure of open pneumothoraces. Local anesthesia and intercostal nerve block was employed for all other procedures involving only the chest wall and for thoracentesis. A physician anesthetist administered all closed anesthesia. Anesthetic agents and the apparatus for their administration are somewhat limited in frontline hospitals with cyclopropane, the agent of choice not available. Ernst,[4] in a discussion of the treatment of thoracic wounds based on observations made during the Polish and French Campaigns, stated that in some cases of open pneumothorax, the administration of evipal sodium was useful. No intravenous anesthesia was used in our group as it was strongly felt that all forms of intravenous anesthesia are contraindicated in early war injuries of the chest.

Aspiration of the tracheobronchial tree at the completion of the operation was done on all patients who received general anesthesia.

EFFECTS OF PRIMARY THORACIC WOUNDS

Hemothorax.—Hemothorax, where varying quantities of blood were found in the pleural cavity as the most important abnormality, occurred in 390 patients, 339 of whom had penetrating wounds and 51 perforating wounds of the chest. In the cases of penetrating wounds, many revealed the presence of retained foreign bodies of small size (smaller than 2 by 1 cm.) which, from the standpoint of effect on early management, were considered nonexistent.

These patients presented the typical signs and symptoms, and x-ray findings of pleural effusion and the blood present in the pleural cavity varied from small accumulations in the sulci, with little or no reduction in vital capacity, to massive accumulations with marked diminution in vital capacity and the classical signs of oxygen want. The etiology of the hemothorax in most cases was bleeding from chest wall and/or lung bleeding.

Hilar structures when involved usually cause death on the battlefield or, if the patients arrive at a hospital installation, they are in such extremis that surgery is not advisable or is futile.

Intercostal arterial hemorrhage as the etiologic factor in hemothorax, the result of stab wounds of the chest, is a common finding in civilian practice. Surprisingly, at no time in this series was intercostal arterial ligation for hem-

orrhage necessary. In many cases, during débridement or exploration, the vessels were visualized and found to be torn but well thrombosed. It is believed that the tearing type of injury with rib comminution that is usually seen, associated with the searing quality of many hot postexplosive missiles, results in a marked contusion of the vessel wall with early thrombosis, as is so often seen in extensive injuries of the extremities. In a personal communication, Berry,[5] on active duty with the Army, stated that he had not encountered intercostal arterial hemorrhage in any of the chest injuries he had treated during the Tunisian Campaign. Zeider,[6] with a Surgical Auxiliary Group, also stated that he had never encountered intercostal hemorrhage in his work in the French and Belgian Campaigns.

Lung bleeding undoubtedly occurs in all cases of hemothorax but is usually self-controlled and rarely recurs. However, a number of patients with extensively lacerated lobes did not control themselves and lung suture was necessary to control hemorrhage.

The management of patients with hemothorax is undoubtedly one of the most important considerations of the thoracic surgeon, especially in frontline hospitals. The greatest error made in the treatment of these cases is that of ultraconservatism, the tendency to leave the patient alone because he is apparently doing very well. Added to this is the utter confusion on this subject that appeared especially in the earlier literature. There are several important considerations in the management of these cases:

1. The Patient: Often during the stress of battle when a hospital is filled to overflowing with battle casualties, the patient as an individual is forgotten. He becomes a "compound femur," a "belly," or a "chest." Patients with chest wounds are often apprehensive and a very important phase of the treatment is the reassurance that all will go well. The hemoptysis and dyspnea are explained and their importance minimized. The knowledge that they have a retained intrapulmonic foreign body often causes great concern, and one must forcibly impress them with the insignificance of retained foreign bodies. Reassurance of resumption of normal lives helps to allay their fears.

2. The Wound: When patients were well stabilized, and only then, was attention directed to the wound. All wounds of entrance, unless grossly infected or very small and clean, regardless of hours after injury, were excised, sprinkled with sulfanilamide powder, and loosely packed with petrolatum gauze. Local anesthesia was used in most débridements. There were no infections of the chest wall in this group.

3. The Hemothorax: The management of the hemothorax has been a subject of considerable controversy in the early war literature. Numerous writers, some with very small series of cases, advocated varied methods of treatment, many of which did not take into account the basic fundamentals of respiratory physiology and the mechanics of pleural space infection. In the early treatment of hemothorax, the surgeon is confronted with three basic considerations: (a) progression of hemothorax, (b) early re-expansion of the lung, and (c) pleural space infection.

(a) Progression of the hemothorax: The determination of the presence of continued hemorrhage becomes the first problem with which one has to deal. The lack of response to adequate shock therapy, or a transient response with rapid return to the shock state, and increasing dyspnea are indications that active bleeding is present. When active bleeding is suspected, thoracentesis is done immediately, and as much blood removed as can be aspirated. Thoracentesis is repeated in one hour and if a large quantity of blood is removed at this second aspiration, one is reasonably certain that active bleeding is present, and exploration of the chest wall or lung or both is indicated. It is only when diagnostic thoracentesis is done early after injury that one might replace the blood removed with an equal quantity of air. The resulting lung compression from the pneumothorax might be of some value in controlling bleeding from lung lacerations, and obviously of no value if the bleeding is from the chest wall.

Autotransfusion was practiced on several occasions following diagnostic thoracentesis. However, it is not very strongly recommended if the time of injury exceeds twelve hours, as gross infection in a hemothorax may occur very early. This was evidenced in two cases in this series in which gross infection of the pleural cavity was noted following penetrating wounds seventeen and twenty-four hours, respectively, after injury. Thoracoabdominal wounds offer another contraindication due to the more likely contamination.

(b) Early re-expansion of the lung: The active management of all patients with hemothorax is concerned primarily with directing treatment toward early re-expansion of the lung. There is one and only one method of treatment which will favor early re-expansion of the lung, namely, early and repeated aspiration without air replacement. Carter and DeBakey[7] adequately sum up the advantages of early aspiration as the procedure of choice in the treatment of hemothorax as follows: (1) it relieves high intrapleural pressure, (2) it removes an excellent culture medium for bacterial growth, (3) it aids in early expansion of the lung—a definite advantage in limiting the area of empyema if infection occurs, (4) it decreases the incidence of massive clotting, and (5) it prevents the later fixation and contraction of the thorax.

In this series, thoracentesis was usually instituted twenty-four hours after wounding, although there was no hesitation felt about aspirating hemothoraces earlier in many cases. In the absence of recurrent shock, aspiration was usually done twenty-four hours after injury because it was believed that the patients were better stabilized both systemically and locally at that time. It must be emphasized that there is no danger of recurrence of bleeding (lung bleeding) as the result of early aspiration. In no case in this series did bleeding recur following aspiration twenty-four hours after injury or in the cases where it was instituted earlier.

How much blood should be removed at each aspiration has been a subject of considerable discussion. During the Algerian and Tunisian Campaigns (107 cases) quantities of blood varying between 400 and 600 c.c. were removed at each aspiration if obtainable, never more. It was observed that the patients from whom 600 c.c. had been removed tolerated the removal very well and that fewer aspirations were necessary for total removal of the hemothorax. In the Sicilian

Campaign (twenty-six cases) between 600 and 800 c.c. of blood were removed at each aspiration. Again it was noted that the patients in whom 800 c.c. of blood were removed tolerated the procedure well and very definitely had earlier re-expansion. In the French and Belgian Campaigns (470 cases) no limit was placed on the amount of blood removed at each aspiration. All patients were aspirated as dry as possible, with quantities as high as 1,500 c.c. having been removed at a single aspiration. The procedure was very well tolerated by all patients, the numbers of aspiration necessary were very definitely reduced, early re-expansion was favored, and the incidence of clotting in the hemothorax was undoubtedly reduced. No sudden deaths occurred at any time as a result of aspiration. The most common untoward effect noted in most patients was referred pain to the shoulder of the affected side, which usually subsided after several hours without sedation. A very small number of patients complained of tightness in the chest, which also subsided after several hours without specific treatment.

Ferguson,[8] in a paper on "Experiences in a Theater of Operations," stated that, "In patients with a hemothorax it was found that pain and fever were increased by repeated tappings, so that it became their policy to reserve this procedure for those cases in which there was dyspnea or in which infection was suspected." This was not the experience of this Service. Although transient pain did occur in many patients as just described, fever in most cases was reduced following repeated aspirations. It is strongly urged that we do not allow ourselves to be deterred from repeated aspirations, especially in the early days of treatment, because of transient discomfort associated with the procedure. The pain of thoracentesis is a most welcome substitute to the invalidism of unexpanded lung and fibrothorax. It is strongly believed at this time that more complete recoveries and a small incidence of unexpanded lung and fibrothorax will result if no limit is placed on the quantity of blood removed at each aspiration. Although daily aspirations were intended, the large numbers of casualties necessitating emergency surgery often made it impossible to carry out this ideal practice. However, if heavy casualty admission forced omission of aspiration for one day, it was never missed the next. Again, the maximum obtainable quantity of blood was always removed at each aspiration.

The question of air replacement may be argued for some time to come. It is mentioned here only to condemn its use in the treatment of hemothorax. It is of no value in controlling bleeding from the chest wall. In this series no patient has shown recurrence of bleeding from re-expansion of the lung after aspiration. In addition, air replacement has a very definite disadvantage, namely, the resulting pneumothorax will temporarily prevent the apex of the lung from re-expanding, or collapse an already expanded apex. If a pleural space infection occurs, a total empyema with its resultant high morbidity and mortality rate may result.

(c) Pleural space infection: In patients with war wounds of the chest, there will undoubtedly always be an incidence of pleural space infection regardless of the care and diligence expended in their management. However, this incidence will be markedly reduced, and in those cases in which infection

results, the space will be a small one if one institutes (1) early and repeated aspiration, (2) no air replacement, (3) removal of large metallic foreign bodies with their adherent organic material and nonmetallic elements such as clothing and rib fragments, (4) chemotherapy, and (5) penicillin therapy, both parenterally and locally.

Supportive treatment of patients with hemothorax included the routine administration of sulfadiazine in dosages of 8 Gm. the first day followed by 6 Gm. daily for the next four days. Initial dose at times was given intravenously if postoperative nausea or other complications prevented its oral administration and retention. Facilities for blood level determinations were not available, but daily urinalysis and biweekly blood counts were done on all patients. Oxygen was administered by a B.L.B. mask to all patients who exhibited dyspnea, with or without cyanosis. Parenteral fluids were administered when necessary, plasma being used freely to overcome protein deficiency. All patients received a full diet supplemented by vitamins C and B. Cough and expectoration were mandatory, and in patients with multiple rib fractures, this process was aided by the use of intercostal nerve block. Single rib fractures were usually not blocked, as most of these patients were not deterred from coughing. Deep breathing exercises every hour were routine. During the French and Belgian and German Campaigns, all patients received penicillin parenterally (intramuscularly) in dosage of 40,000 units initially, followed by 20,000 units every four hours for seventy-two hours. Following a personal communication from Bailey[9] of Hahnemann Hospital, Philadelphia, with whom one of us (F. T., Jr.) was formerly associated, on the use of penicillin intrapleurally, patients with hemothorax were treated by the instillation of 30,000 units of penicillin in 4 c.c. of normal saline solution into the pleural cavity following each aspiration. The value of this procedure must be determined by reports of investigation in rear echelons where these patients were under observation during the periods when pleural space infections are most likely to occur. Two very important questions must be answered before this procedure can be routinely used: (1) Does the irritating nature of locally instilled penicillin increase pleural exudation? (2) Does the local use of penicillin increase clotting in the hemothorax? Clinical observations in more than 100 patients in whom penicillin has been instilled intrapleurally following thoracentesis have given the impression that the incidence of clotting in the hemothorax has increased. The question of using sodium citrate intrapleurally to prevent or decrease clotting in the hemothorax was considered but not used.

There were 14 deaths in the group of 339 penetrating wounds, 11 nonoperative and 3 operative. The nonoperative deaths represent patients who were admitted to the hospital in profound shock and who died shortly after admission despite vigorous shock therapy. The operative deaths represent patients in whom at least wound excision and thoracentesis were carried out. Death in one patient occurred as a result of shock following thoracotomy for removal of a very large foreign body. It is believed that this death could have been prevented if sufficient blood could have been administered during surgery. The blood available at this time was stored blood, the administration of which presented

many technical difficulties during the early days of its use, so that despite numerous attempts and adaptations, the patient received only 300 c.c. of whole blood during and immediately after the procedure. These technical difficulties were for the greater part later overcome, but a large percentage of reactions still occurred. The second patient, with a relatively simple infection of the pleural space that had been tapped practically dry, developed an acute pulmonary edema on the fifth day after injury and died. Despite autopsy, the etiology for the pulmonary edema could not be determined. The third patient, a prisoner of war, doing very well, developed convulsions on the eighth postoperative day during a transfusion and died within ten minutes. Cross-matching had been satisfactory.

In those with perforating wounds complicated by hemothorax (fifty-one cases), there was one death from shock and hemorrhage in a case with bilateral hemothorax, the result of four perforating wounds. Two other patients with bilateral hemothorax, however, recovered.

Infected Hemothorax.—In forward hospital installations, where early battle casualties are treated and evacuated as soon as they are transportable, the incidence of sepsis in a hemothorax is extremely low as this complication is usually not seen until the second week after injury or later. Serbst,[10] in a personal communication, following a tour of the chest centers in the North African Communications Zone, stated that many patients developed pleural space infections many weeks after injury, and that the prevalent opinion at that time was that the routine use of chemotherapy delays or modifies the appearance of the complication. Seven patients in this series presented findings of infection in the hemothorax during their hospital stay. Two patients were admitted with infected hemothoraces and are of interest because of the unusually short time after injury in which both these cases presented a grossly infected hemothorax. These patients were admitted seventeen and twenty-four hours, respectively, after injury in extreme shock, markedly dyspneic, and irrational. Aspiration revealed a chocolate colored fluid with a colonic odor which permeated the entire tent. The first patient died twelve hours after admission. The second patient was aspirated on two successive days, followed by the establishment of closed drainage. The patient was evacuated on the sixth day after admission in fairly good condition.

Management of these cases in this type of medical installation consisted of repeated aspirations followed by closed intercostal drainage several days before the patient was evacuated. Open drainage is never done early, which means never in semimobile Evacuation Hospitals.

The use of penicillin parenterally and locally will probably markedly reduce the morbidity and mortality in this group of patients.

Closed Pneumothorax.—Fifteen patients in this series presented a closed pneumothorax of varying size. Facilities were not available for measuring intrapleural pressures. It was noted that in a majority of these cases, wounds were in the upper anterior portion of the chest, the incidence of location being divided fairly evenly between the supra- and infraclavicular regions. In most cases, wounds of entrance were small. Management consisted of wound excision

and bed rest. In no case was it felt necessary to decompress the pneumothorax. No patient was returned from our institution to duty, all having been evacuated to the rear. There were no deaths in this group of patients.

Open Pneumothorax (Sucking Wounds).—Eighty-one patients with an open pneumothorax, the result of penetrating wounds, and 49 patients with this type of defect from perforating wounds were admitted to the chest service (total, 130). With the exception of the combined thoracoabdominal wounds, this group of patients probably represents the most serious of all chest injuries. Although as a rule patients with chest wounds transport well, patients with sucking wounds, unless tightly sealed by dressings or properly closed by suture, transport poorly. Early adequate management at the first aid and clearing stations determined the condition in which patients arrived at the hospital installation. One cannot emphasize too strongly the fact that the most intensive measures at resuscitation are to no avail if an open pneumothorax is not completely closed at the earliest possible time. It must be understood that by complete closure one does not refer to surgical closure. Adequate closure at these stations could be accomplished by large strips of petrolatum gauze bridged over the open wound and a large gauze pad (abdominal) secured in place over it by a tightly applied three-inch adhesive plaster. At the clearing station, resuscitative measures are instituted and dressings reinforced if they have become loosened in transportation. Surgical closure at these stations, contrary to policy, consisting of only through-and-through sutures or simple airtight closure of the skin is to be condemned. Subcutaneous emphysema in these cases may extend from the forehead to the scrotum. Properly applied occlusive dressing is definitely preferred to inadequate closure without wound excision, or simple packing, which is inefficient. On admission to the hospital, all dressings were checked specifically and reinforced or reapplied if inadequate. In cases in which skin closure had been done, sutures were removed and occlusive dressings applied while the usual resuscitative measures were being instituted.

It was found in a number of patients with apparently simple penetrating wounds not exhibiting open pneumothorax that forceful cough while the wound was directly observed would project a column of blood (hemothorax fluid) from the wound, and open pneumothorax could thus be demonstrated. This clinical test was carried out on all patients before surgery, as it is most important to determine whether a case is one of so-called "masked open pneumothorax." The type of anesthesia to be used and the operative procedure indicated are directly affected by the diagnosis of the type of injury present. In patients with perforating wounds, the exit wound was of course the open wound, but frequently both entrance and exit wounds were found to be of the sucking type.

It was the policy of our service that no patient in shock, unless actively bleeding, was ever subjected to surgery until after recovery from shock. Following recovery from shock, anteroposterior and lateral x-ray views of the chest, fluoroscopy, and a flat plate of the abdomen were taken and patients brought to the operating room. Endotracheal closed anesthesia with positive pressure technique was used in all cases, and occlusive dressings were not removed until the anesthetist had the patient well controlled. Complete wound excision was

done in all cases and fragmented rib ends were resected. Pleural toilet was usually adequately carried out through the débrided wound by the use of rib retractors, or in some cases the wound was enlarged by incision and the removal of a segment of the already fractured rib. Pleural toilet included aspiration of all blood and clots by suction, removal of bone fragments from the pleural cavity and lung (a common finding), removal of foreign bodies if readily accessible, saline lavage of the pleural cavity, lung suture, and the instillation of 5 to 10 Gm. of sulfanilamide into the pleural cavity. Muscle layer closure was done using interrupted catgut sutures, sulfanilamide powder having been sprinkled over each muscle layer. The skin and subcutaneous tissue was left open in all cases. In only one case, with a large defect in the chest wall close to the spine and extensive lung laceration, was it impossible to effect muscle closure. In this patient, the lung laceration was repaired and the affected portion of the lung sutured to the edges of the thoroughly excised open wound. Exploratory thoracotomy through a separate clean incision will be discussed under the heading of Retained Foreign Bodies and Exploratory Thoracotomies. Brock[11] advocated closure of an open pneumothorax and drainage of the pleural cavity with an airtight system. Closed drainage was used in this group only in those cases where extensive intrapleural damage had existed. In the others, pleural accumulations were aspirated as was necessary. Surgical closure was not done if the wounds were septic, occlusive dressing being used in those cases (only one case).

Postoperatively, these patients received the same type of treatment as described under hemothorax, as did all patients in this series. In those patients in which closed drainage was instituted, drainage tubes were usually removed after forty-eight hours. There were 17 deaths in this group of 130 cases, 4 nonoperative and 5 operative in the penetrating type; 6 operative and 2 nonoperative in the group with perforating wounds. The nonoperative (6) deaths represent patients who arrived at the hospital moribund. The 11 operative deaths occurred in cases as follows: (1) A patient with open pneumothorax and associated tracheal and esophageal laceration. The neck was débrided, surgical tracheotomy performed, and the esophageal laceration repaired. The neck wound was packed open. The open chest wound was closed by occlusive dressing as the patient's condition did not permit further surgery. Sudden death occurred on the fifth postoperative day when the patient was apparently making a good recovery. Cause of death was undetermined as circumstances beyond our control prevented autopsy being done. Embolic phenomenon was suspected. (2) A patient with open pneumothorax and associated transection of the cord at the level of the fifth thoracic vertebra. Death occurred on the fifth postoperative day and was attributed to the cord lesion. (3) A patient with open pneumothorax with retained foreign body of large size in the hilar region of the lung. The foreign body was removed, and the superior vena cava was found to be contused, with no bleeding. The patient died as the procedure was completed. Autopsy revealed that the contused portion of the superior vena cava had "blown out." (4) A patient with open pneumothorax; fracture, compound, comminuted, of the left femur; fracture, compound, comminuted, of the

right os calcis and left ulna. The patient died immediately after surgery, from shock. (5) A patient with open pneumothorax and penetrating wound of the brain. The patient died immediately after closure of open pneumothorax, of shock. (6) A patient with perforating wound with anterior and posterior open pneumothoraces, severe wound of the left thigh (femoral artery partially severed or thrombosed). The left lower lobe of the lung was one solid hematoma, the diaphragm was split in two and the stomach was in the chest. Surgical repair was done. Death was from shock in early postoperative period. (7) A patient with open pneumothorax, extensive lung lacerations, severe head injuries with persistent unconsciousness. Death followed. (8) A patient with open pneumothorax; compound fracture of both bones of the right forearm; multiple penetrating wounds of right thigh. Death was from shock. (9) A patient with open pneumothorax with severe comminution of the left sixth, seventh, and eighth ribs. Death occurred while the patient was on the operating table; cardiac injury was suspected. (10) A patient with anterior and posterior open pneumothorax (perforating wound) and tension pneumothorax after closure, from open inaccessible pulmonary wound; decompression. Death was from shock. (11) A patient with open pneumothorax. It was closed. Death was sudden and unexplainable on the fifth postoperative day.

Tension Pneumothorax.—Tension pneumothorax is an infrequent complication of penetrating wounds of the chest which equals open pneumothorax as a thoracic emergency. The diagnosis of a tension pneumothorax is not difficult if the condition is kept in mind. The patient's critical condition makes detailed examination almost impossible; however, the intense dyspnea, bulging relatively fixed chest, tense accessory muscles of respiration, hyperresonant percussion note, and mediastinal shift are more than sufficient to establish a diagnosis. A valuable sign of displacement of the mediastinum is the readily palpable shift of the trachea from the midline in the suprasternal notch.

Treatment is simple and in most cases dramatic in effect. A needle of fairly large caliber is inserted into the chest through the second interspace in the midclavicular line which allows the excess air to escape. In continued decompression in the valvular type cases, a flutter valve is attached to the end of the needle, this usually being fashioned from a finger cot or condom. Hospital management usually employs closed drainage with a 15 gauge needle or catheter. For transportation purposes a suitable apparatus is the use of a flutter valve attached to a 15 gauge needle which is passed through a rubber stopper of a saline flask and then inserted into the chest. The stopper is firmly strapped to the chest wall with adhesive tape and the patient may be moved without fear of displacing the needle. Response to this management is sudden and effective; within a few hours, a patient who was virtually fighting for his life is breathing calmly and resting comfortably. Decompression can usually be discontinued within twenty-four to forty-eight hours except in some of the valvular types, when it must sometimes be continued for seven days.

The literature makes numerous references to the development of tension pneumothorax following the closure of open pneumothorax. This complication occurred in only one patient in this series following closure of open pneumo-

thorax. Prevention of this complication is achieved by repair of the lung laceration itself.

There were five patients with primary tension pneumothorax (preoperative) in this series, with one death. The death was in a patient who was not seen until thirty-six hours after injury, at which time he was moribund. The patient died as a needle was thrust into his chest.

Pulmonary Hematoma.—Pulmonary hematomas form an interesting entity. Rare after penetrating wounds, they are not infrequently associated with perforating wounds or severe tangential blows to the chest. Involving a portion of a lobe and sometimes an entire lobe, they result from interstitial pulmonary bleeding. Hemoptysis is always present in these cases. They are usually not associated with a hemothorax, although some of the patients develop a hemothorax twenty-four to forty-eight hours after injury. The course of these patients is usually a very smooth one. Other than wound excision, thoracentesis, and supportive treatment, no active treatment was used. When severe, pulmonary hematoma may contribute greatly to the cause of death. In the sixth case fatality under open pneumothorax, the diaphragmatic rent and lower lobe hematoma were blast effects laterally transmitted from the perforting wound. There were three other deaths: (1) Pulmonary hematoma, right side, developed bradycardia of 40 beats per minute on fourth postoperative day; temporarily improved by oxygen; unexplained fatal termination three days later. (2) Closed chest injury, tangential perforating chest wall wound produced hematoma of upper, middle, and lower lobes on the right, without rib fracture. (3) Prisoner of war struck in left anterior chest with large searing explosive missile; hematoma and death.

CARDIAC WOUNDS

Cardiac wounds are rarely seen in hospital installations, because most of them result in death on the battlefield. Eight patients were admitted to the chest service with so-called cardiac wounds. Five patients presented metallic foreign bodies of small size (less than 1 cm.) embedded in the myocardium; four patients were admitted with lacerations of the heart; two of the left ventricle; one of the right auricle; and one of the right ventricle. The patients that presented metallic foreign bodies in the myocardium, aside from showing physical signs of a small hemothorax of the left side, were in excellent condition. There were no signs of tamponade at any time nor were there any cardiac arrhythmias. Diagnosis in all cases was made by fluoroscopic study.

The management of these cases was a conservative one. No attempt was made in any patient to remove the foreign body. Aspiration of the hemothorax was carried out as usual. In a personal communication, Churchill[12] informed us that one patient was in excellent condition and no attempt had been made or would be made to remove the foreign body. Bland[13] encountered eight patients with retained metallic foreign bodies either in or in close apposition to the heart. A favorable outcome in all patients by conservative management is reported.

The patient with a laceration of the right auricle also presented a large metallic foreign body (3 by 2 inches) lying free in the right pleural cavity. A right-sided exploratory thoracotomy was done with closure of the cardiac lacera-

tion by four silk sutures. The pericardium was closed by interrupted silk sutures except for the lower angle near its attachment to the diaphragm which was left open and communicated with the right pleural cavity. The foreign body was removed and pleural toilet carried out. It was noted that the phrenic nerve as it entered the diaphragm was lacerated with paralysis of the right diaphragm. Closed drainage was not used in this case. The patient made a good recovery and in a personal communication several months later stated that he was doing well. One of the patients with a laceration of the tip of the left ventricle was listed under combined thoracoabdominal wounds. The laceration did not extend into the chamber of the ventricle. Three interrupted silk sutures were required for closure and there had been considerable hemopericardium. The patient with the lacerated right ventricle also had a wound that did not enter the chamber of the right ventricle. Four interrupted silk sutures were required for closure.

The only death in the group occurred in a patient with a lacerated wound of the right anterior part of the chest through the left anterior part of the chest with fractures of five ribs and fracture with loss of substance of the lower end of the sternum and bilateral hemothorax. There was a laceration of the left ventricle three inches in length, which did not enter the cavity of the ventricle. Exploration was carried out through the débrided wound. The lacerated ventricle was sutured with interrupted silk sutures following the use of novocain locally. Cardiac standstill occurred four times during surgery and cardiac rhythm was re-established by hand massage. Adequate closure was carried out. The patient died two hours after surgery without regaining consciousness.

COMBINED THORACOABDOMINAL WOUNDS

Sixty-five patients were admitted to the chest service with combined thoracoabdominal wounds; 31 of the left side, 34 of the right side. Although the series is small, it is believed that some pertinent observations have been made that may be of value in the future management of these cases. Subdivision of these wounds into those of the left side and right side is done for purposes of presenting the more common findings in the lesions and their management.

Shock of a profound nature is the rule in these patients with hemorrhage the result of liver lacerations as a contributory and often the etiologic factor on the right side, and perforation of a hollow viscus and/or splenic laceration on the left side. The liberal use of whole blood must be stressed in the treatment of these cases. Unless active bleeding was present, surgery was deferred until recovery from shock had taken place.

Recovery is usually directly proportional to the degree of intraperitoneal involvement. In most patients, wounds of entrance are in the lower portions of the chest with little resulting damage to intrathoracic structures. Open pneumothorax is probably the most common serious thoracic lesion. Injury to hollow viscera occurs infrequently on the right side.

There were two patients in this group who presented a condition which it is believed has not heretofore been described in the literature and which has been termed "tension pneumothorax of peritoneal origin" to denote its etiology. In both patients wounds of entrance were in the left lower part of the chest an-

teriorly with large perforations of the anterior wall of the stomach with a resultant outpouring of a large volume of air into the chest through the lacerated diaphragm. The condition was recognized in one patient and closed drainage instituted, however, not until several hours after admission. In the other patient it was not recognized and the patient died during laparotomy. Churchill[14] who was present at the autopsy performed on one of these patients, when asked if he thought this condition was possible, was of the opinion that tension pneumothorax of peritoneal origin was possible with the previously mentioned lesions; although prior to autopsy, there had been some controversy as to its feasibility. This condition is obviously not anticipated in combined wounds of the right side.

One cannot overlook the possibility of an "internal sucking wound" on the left side, in which small quantities of air and intestinal contents are aspirated into the chest during the act of respiration. No matter how small the quantity of air may be, altered intrapleural pressures result, with noticeable effect on the patient. During laparotomy in left-sided combined thoracoabdominal wounds, an internal sucking wound becomes a true sucking wound on opening the peritoneum. It must be stressed that next to the control of active hemorrhage, closure of the lacerated diaphragm should be the first duty of the surgeon on opening the abdomen. Pleural space infection from contamination by intestinal contents is to be anticipated. In lesions of the right side, an internal sucking wound is prevented by the liver and its attachments.

In the management of these cases, early operation after complete recovery from shock is imperative, unless active bleeding is present, in which case surgery must often be instituted before shock has been properly controlled. X-ray and fluoroscopic studies of the chest and abdomen were done prior to operation. Endotracheal closed anesthesia (nitrous oxide, oxygen, ether) was routine.

McGrath[15] stated "that penetrating wounds communicating with the peritoneal cavity require exploration of both cavities." Separate exploration of both chest and abdomen was avoided in this series whenever possible.

Throughout the greater number of the campaigns, we approached most left-sided lesions through an abdominal incision, especially if the wound of the chest was small, nonsucking, and the diaphragmatic rent could be closed reasonably well from below. If considerable abdominal involvement is suspected, transdiaphragmatic approach has definite limitations; although for wounds involving or only traversing the left upper quadrant of the abdomen and lower chest, a transpleural transdiaphragmatic approach has allowed at least six splenectomies with ease and celerity as well as nephrectomies and gastric, colon, and upper small intestinal repair. Frequently, with small open pneumothoraces, these have been débrided, the pleural cavity cleansed, sulfanilamide powder introduced, and the wound closed, with the main procedure then carried out transabdominally. These patients almost all required closed intercostal drainage. If, however, one anticipates a large pulmonary wound, transthoracic approach allows its repair and lessens the danger of a postoperative tension pneumothorax.

In right-sided lesions, intestinal involvement is the exception rather than the rule, the abdominal damage being confined to the liver. Transpleural approach in these injuries was always done, with repair of the lacerated liver and

diaphragm, and establishment of drainage of the subphrenic space in addition to closed intercostal drainage of the pleural cavity. When laparotomy was necessary, it was done through a separate abdominal incision rather than the forward extension of the thoracic incision. Laparotomy was rarely necessary. Drainage of the subphrenic space is an important step in the management of right-sided combined thoracoabdominal wounds and should be instituted in all cases. This dictum was forcibly brought to the attention of this service in a follow-up report of a patient in whom subphrenic drainage had not been instituted because it was felt at the time of surgery that the hepatic damage was minimal and drainage could be accomplished only by extending the small laceration of the diaphragm by incision. The patient developed a thoracobiliary fistula with empyema, and wide open drainage was instituted at the chest center.

Postoperatively, shock was treated by the liberal use of whole blood, and oxygen was administered routinely for at least twenty-four hours. In left-sided lesions the patients were placed on a routine of (a) nothing by mouth, (b) continued duodenal suction, (c) fluid balance (3,500 c.c. daily: 2,000 c.c. 5 per cent glucose in distilled water, 500 c.c. plasma, 5 per cent glucose in saline solution equal to the amount of fluid recovered by suction), (d) penicillin intramuscularly, (e) sodium sulfadiazine, 5 Gm. initially followed by 2 Gm. every eight hours intravenously, (f) vitamins C and B_1 parenterally, (g) blood and urinary studies every two days. In right-sided lesions unless laparotomy was performed, patients were usually able to tolerate oral feeding.

There were 22 deaths in this group of 65 cases; 14 operative or postoperative, and 8 nonoperative, a total mortality rate of 33.8 per cent. The nonoperative deaths represent patients who arrived at the hospital in profound shock, with no response to intensive therapy, and who usually died within a few hours after admission. The operative deaths are listed as follows: (1) Left—laparotomy, peritonitis following the resection of a segment of ileum and suturing of multiple intestinal perforations; (2) right—mechanical ileus arising from localized abscess about a perforation of the hepatic flexure of colon (perforation not recognized); (3) left—laparotomy, multiple gastric and intestinal perforations; operative shock and the effect of tension pneumothorax of peritoneal origin; (4) right—thoracotomy and laparotomy, hemoperitoneum, sudden death on the fifth day; (5) left—cord injury, splenectomy, nephrectomy, closure of open pneumothorax, shock; (6) right—laparotomy, multiple intestinal perforations, shock; (7) left—laparotomy, ruptured left lobe of liver, compound fracture of skull, compound fracture of left tibia, shock; (8) right—thoracotomy, open pneumothorax, right lobe of liver split through its entire length, shock from persistent bleeding despite packing; (9) left—open pneumothorax, closure, laparotomy, multiple gastric and intestinal perforations, shock; (10) left—open pneumothorax, laparotomy, intestinal resection, shock; (11) left—open pneumothorax, thoracotomy, splenectomy, closure of gastric perforations, shock; (12) left—open pneumothorax, débridement and closure; laparotomy, suture of extensive lacerated left lobe of liver, shock; (13) left—transpleural splenectomy, died twenty-four hours after surgery; (14) left—hemothorax, débridement wound, laparotomy, splenectomy, died twenty-four hours postoperatively, acute pulmonary edema.

CHEST AND ABDOMEN—NOT COMBINED

The group of patients with chest and abdominal injuries, not combined, present the same problem in management as do those with combined thoracoabdominal wounds. Laparotomy was always necessary, and conservatism was practiced in the management of the thoracic aspect. There were 11 patients treated, with four deaths. The mortalities are listed as follows: (1) Civilian, 2 years of age; open pneumothorax, closure, laparotomy, closure of multiple perforations, peritonitis. (2) Hemothorax, conservative management; laparotomy, retroperitoneal hematoma; débridement and fixation of compound fracture neck of left femur, shock. (3) Open pneumothorax, closure; laparotomy, closure of multiple perforations, shock. (4) Hemothorax aspirated, laparotomy, splenectomy; died twenty-two hours postoperatively of acute pulmonary edema.

BLAST INJURIES

Eight patients with clinical and x-ray findings of blast injury to the lungs were included in this series. The principal symptoms present were moderate to severe shock, hemoptysis, dyspnea, cyanosis, pain in the chest, and marked restlessness to maniacal delirium. Physical findings are usually increased respiratory rate; impaired resonance to dullness on percussion, usually more marked on one side; diffuse moist râles over both sides, with scattered areas varying to an entire lobe in size over which breath sounds are markedly diminished and of a bronchovesicular nature. Three patients in this group developed a hemothorax despite the absence of any external signs of injury.

Treatment consisted of the use of warmth, oxygen therapy (oxygen under pressure preferable) which must in some cases be continued for days, and the judicious use of fluids (blood and plasma), particularly in the early phases. The associated injuries which are usually present often determined the amount of fluids necessary. The use of human serum albumin in 100 c.c. doses every four hours for three or four doses was administered in three cases and gave the impression of being of some benefit. Sedation is nearly always necessary because of the cerebral symptoms, but it is given sparingly. Morphine was the drug used and never in doses greater than ¼ gr. Sulfonamides were used routinely as was penicillin when it became available. Cough and expectoration are imperative, as the patients accumulate large quantities of frothy mucous in the tracheobronchial tree which favors anoxia by decreasing minute volume exchange. If surgery is necessary for associated injuries, general anesthesia should be avoided.

There were three deaths in this group: (1) Pulmonary and cerebral blast with unconsciousness and signs of meningitis; autopsy revealed numerous petechial hemorrhages through brain and lungs. (2) Pulmonary blast with compound fracture of left femur. (3) Pulmonary and cerebral blast, compound fracture of left femur, compound fracture of left ulna.

CLOSED INJURIES

Closed injuries usually result from the recoil of artillery pieces, smashed vehicles, or the impact of any blunt object (large stone or other bomb debris).

No patient of those treated presented the so-called "stove-in chest." Multiple rib fractures were present in nine patients and single rib fractures in two. Paradoxical breathing was not marked in any patient. Intrapleural involvement was one or a combination of, spontaneous pneumothorax, tension pneumothorax, and hemothorax. Two patients presented tension pneumothorax with hemothorax, one of these occurring on the opposite side from the site of injury.

Treatment consisted chiefly of measures to relieve whatever intrapleural derangement existed. Intercostal nerve block was used in multiple rib fractures to enhance cough. Elevation of the chest wall by means of traction devices was not necessary in any case.

There were thirteen patients in this group, with two deaths. These two fatal cases have been discussed under pulmonary hematomas.

RETAINED FOREIGN BODIES AND EXPLORATORY THORACOTOMY

The management of retained foreign bodies is a subject of considerable discussion in the present-day literature. The type of foreign bodies, size, location, the symptoms produced, and optimum time for removal are important considerations.

The type of retained foreign bodies encountered in war injuries of the chest in the order of their frequency were: (1) metallic fragments, (2) rib fragments, (3) clothing, (4) wood (rare), (5) stones, pebbles, debris (most rare), (6) a combination of one or more, metallic fragments plus clothing plus rib fragments, a common finding. It is generally agreed that the lung and pleura tolerate most metallic foreign bodies well, but that rib fragments, clothing, and debris are frequently responsible for infection, and that the latter must be removed. X-ray and fluoroscopic studies readily reveal the presence of metallic foreign bodies but clothing, most rib fragments, and rubble are not radiopaque. The presence of rib fragments, cartilage, and clothing can be determined only by inference based on experience. Almost invariably roentgenologic evidences

TABLE I. TABLE OF INJURIES

TYPES OF INJURIES	NO. OF CASES	PENETRATING	MORTALITY OPERATIVE	MORTALITY NONOPERATIVE	PERFORATING	MORTALITY OPERATIVE	MORTALITY NONOPERATIVE
Hemothorax	390	339	3	11	51	0	1
Infected hemothorax	7	7	1	0	–	–	–
Closed pneumothorax	16	15	0	0	1	0	0
Open pneumothorax (sucking wounds)	130	81	5	4	49	6	2
Tension pneumothorax	5	4	0	1	1	0	0
Pulmonary hematoma	25	–	–	–	25	1	0
Cardiac wounds	8	8	1	0	–	–	–
		Left Side			*Right Side*		
Combined thoracoabdominal	65	31	10	6	34	4	2
Chest—abdomen, not combined	11	11	4	0	–	–	–
Blast injuries	8	8	0	3	–	–	–
Closed injuries	13	13	0	2	–	–	–
Total chest injuries	678						
Total mortality, 9.6 per cent							

of comminuted rib fractures mean spicules of rib in the pleural cavity or lung. Surprisingly, these fragments do not visualize on x-ray examination, usually because of the increased density present as a result of the hemothorax present. In one case, a fragment of rib two inches long was removed from the pleural cavity. It had not visualized on x-ray examination but its presence was known because the fractured rib from which it originated presented a defect corresponding to the foreign body. The presence of clothing can only be suspected when large, irregular foreign bodies are visualized. Experience has shown that large irregular foreign bodies (2 by 1 cm. or larger) often carry clothing in with them.

The size of the foreign body had a direct bearing on the decision for removal. Large irregular foreign bodies greater than 2 by 1 cm. were usually removed because they (a) often caused cough, hemoptysis, and pain; (b) probably carried clothing in; (c) usually caused rib comminution with rib fragments driven into the lung or pleural cavity; (d) produced a psychosomatic effect on the patient; and (e) most often caused large lung lacerations.

The location of a foreign body was of considerable importance, we felt, because of the complications which might arise therefrom. Foreign bodies located near the great vessels, near the esophagus, or lying free in the pleural cavity were removed early. It was during exploration for hemorrhage associated with a large retained foreign body that an active laceration of the auricle was successfully closed. Foreign bodies of small size embedded in the myocardium are usually treated conservatively, that is, not removed.

The signs and symptoms present in early cases are usually those produced by intrapleural derangement, cough, dyspnea, hemoptysis (frequent), and pain in the chest.

As to the optimum time for removal when one has decided that a foreign body should be removed, Carter and DeBakey[16] stated that "it has been considered far safer to remove a foreign body in a lung after equilibrium has been established which usually occurs in from three to ten days." It has been the belief of this service that there are two optimum times for removal of retained foreign bodies of large size (2 by 1 cm. or larger): (1) at the time of primary operation and (2) eight or more weeks later. It is understood that when one speaks of removal of foreign bodies at the time of primary operation, it is presupposed that the patient's condition warrants thoracotomy. The reasons for removing foreign bodies at the time of primary operation are as follows: (1) general anesthesia must usually be employed for débridement because the wound is usually too large for excision under local anesthesia or, as is often the case, open pneumothorax is present; (2) because of the size of the foreign body, rib fragments (usually) and clothing are probably contaminants; (3) the foreign bodies can be removed with little manipulation without the need of incision of pulmonary tissue as the fragments are easily and readily removed through a visible wound in the lung; (4) a complete operation is performed including repair of the lacerated lung, with little added risk to the patient, thereby avoiding a secondary operation for late removal, while preventing further major blood loss or accumulation of air in the pleural cavity; (5) sources of infection

are removed, thereby reducing the incidence of infection; (6) the weeks to months of worry and fretting on the part of many patients is obviated (psychosomatic effect).

If it is deemed advisable because of a patient's poor condition to defer removal of the foreign body, then it is believed that its removal should not be attempted for a period of eight weeks or longer, at which time maximum expansion has occurred, infection if present is evident, and a residual clotted hemothorax if present is evident at this time and thoracotomy indicated.

It is believed that the removal of foreign bodies during the so-called period of re-expansion and localization (from the time aspiration is instituted, usually the second day, to the time of either maximum expansion or localization of pleural space infection) is contraindicated because during this time the hemothorax is being emptied, re-expansion promoted, adhesions are forming, and infection if occurring is being localized. To do a thoracotomy at this stage is to invite total empyema. The great majority of infections of the pleural space in battle casualties have manifested themselves relatively late, and thoracotomy during this period when infection is masked probably because of chemotherapy would not seem to be to the benefit of the patient.

Exploratory thoracotomy was done in 102 cases in this service with the procedures shown in Table II.

TABLE II

PROCEDURE	NUMBER
Removal of metallic foreign bodies	28
Lung suture and removal of rib fragments	23
Diaphragmatic repair with:	42
Splenectomy	6
Liver repair	32
Repair of stomach	1
Hernia (entire stomach)	1
Repair of large bowel	1
Nephrectomy	1
Heart suture	4

Pneumonectomy or lobectomy was never done, as no case presented indications for this radical procedure. Partial pulmonary resection was done in one case.

EVACUATION

Patients were evacuated to the rear between the fourth and fourteenth day after injury with an average of about a seven-day stay in the hospital. At the time of evacuation, all patients were in good condition for prolonged transportation. Too early evacuation of patients with chest wounds is not advisable, as pleural exudation may continue for many days and, unless aspirated and the pleural cavity kept as dry as possible, a higher incidence of complications will result.

LATE COMPLICATIONS

An official tour of American Army General Hospitals in England by one of us (J. M. S.) for purposes of late follow-up studies on wounds in general for the Army allowed an opportunity of learning the relative incidence of late com-

plications in patients with chest wounds evacuated from the forward hospitals. As the patients evacuated with chest wounds were not segregated except when complicated, the wide dissemination of these cases to different hospitals made specific case follow-up rather difficult and prevented the determination of accurate incidence figures for the various complications. Until some time when the Army presents a complete over-all picture, these will not be known. However, quite a few of the cases from our series were traced and the various complications in these, the examination of numerous other case records, and the composite opinions of those interviewed in all the hospitals visited handling these patients, including three of the major chest centers, may be summarized as follows:

1. Clotted hemothorax or fibrothorax: The incidence of this complication was increased after thoracotomy or repair of severe chest wounds such as open pneumothoraces. Unless adequate provision has been made to insure and maintain postoperative expansion of the lung by keeping the pleural cavity aspirated dry until the exudative phase is past, the ensuing fibrothorax would necessitate a second late thoracotomy for decortication. This procedure was being carried out six to eight weeks postwounding, even in the presence of minor degrees of infection with apparently a low morbidity and mortality. The relatively frequent incidence of fibrothorax is easily understood when one considers the increased amount of thromboplastic substance which must be poured forth from the traumatized tissues in these large chest wounds. Large clots are frequently encountered in the pleural cavity at the time of operation less than twenty-four hours after wounding.

2. Thoracoabdominal Wounds: The most common complication was the severe empyema following repair of the perforated diaphragm above wounds of the liver when the latter was not drained by the subphrenic route. A thoracobiliary fistula followed. Best results were obtained if early drainage was instituted both above and below the diaphragm.

3. Empyema:

(a) As noted, thoracoabdominal wounds are frequently thus complicated. Soilage by biliary secretions on the right side and gastric or colonic contents on the left side make this quite understandable.

(b) Unsutured lacerations of the lung were considered in one chest center to be the commonest cause of mixed empyemas. Bronchopleural fistulas of small size were also being encountered.

(c) Empyema was more often associated with retained large foreign bodies; although under 2 cm. in diameter, there seemed to be little relative difference.

(d) The composite opinion in hospitals receiving chest cases in general (not chest centers receiving mainly complicated cases by transfer for treatment) was that the over-all incidence of empyema was definitely less than 5 per cent.

(e) The incidence of early abscess of the lung has been almost negligible.

(f) The late mortality of war injuries of the chest was found to be well under 1 per cent. It was the universal opinion that 80 to 85 per cent of those with chest wounds were being rehabilitated successfully for return to full duty.

SUMMARY

1. A series of 678 consecutive war injuries of the chest is presented.

2. The type of injuries, numbers, and mortality rates are recorded in Table I.

3. Preoperative management is discussed in detail.

4. The forms and types of anesthesia used are described.

5. Pathologic conditions following wounds of the chest include: (a) hemothorax, (b) infected hemothorax, (c) closed pneumothorax, (d) open pneumothorax, (e) tension pneumothorax, (f) cardiac wounds, and (g) pulmonary hematoma.

6. Combined thoracoabdominal wounds were subdivided into those on the left side and those on the right side. Tension pneumothorax of peritoneal origin and "internal sucking wounds" are described.

7. Wounds involving both chest and abdomen, but not combined, are presented.

8. Blast injuries are briefly described as to symptoms and treatment.

9. Closed injuries of the chest are very briefly described.

10. Retained foreign bodies and exploratory thoracotomy and late complications are discussed.

11. All patients received chemotherapy. The majority of patients also received penicillin parenterally and many, locally.

REFERENCES

1. Sanger, P. W.: Evacuation Hospital Experiences With War Wounds and Injuries of the Chest, Ann. Surg. **122**: 147, 1945.
2. Snyder, H. E.: The Management of Intrathoracic and Thoraco-Abdominal Wounds in the Combat Zone, Ann. Surg. **122**: 333, 1945.
3. Welch, C. S., and Tuhy, J. E.: Combined Injuries of the Thorax and Abdomen, Ann. Surg. **122**: 358, 1945.
4. Ernst, M.: Die Versorgung der Brustverletzten bei den vorderen Sanitätseinheiten, München. med. Wchnschr. **88**: 485-489, 1941.
5. Berry F. B.: Personal communication.
6. Zeider, G.: Personal communication.
7. Carter, B. Noland, and DeBakey, Michael E.: Current Observations on War Wounds of the Chest, J. Thoracic Surg. **13**: 282, 1944.
8. Ferguson, L. K.: Experiences in a Theater of Operations, Bull. Am. Coll. Surgeons **29**: 100, 1944.
9. Bailey, C. P.: Personal communication.
10. Serbst, C.: Personal communication.
11. Brock, R. C.: Chest Surgery in War; Drainage of the Pleura, Brit. M. J. **2**: 128, 1941.
12. Churchill, E. D.: Personal communication.
13. Bland, E.: Foreign Bodies in and About the Heart, Am. Heart J. **27**: 588, 1944.
14. Churchill, E. D.: Personal Communication.
15. McGrath, E. J.: Wounds of the Chest, J. A. M. A. **124**: 488, 1944.
16. Carter, B. Noland, and DeBakey, Michael E.: Current Observations on War Wounds of the Chest, J. Thoracic Surg. **13**: 285, 1944.

ENDOMETRIOSIS OF THE INTESTINAL TRACT

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KNOWLEDGE that ectopic endometrium may have wide, although not unlimited, extragenital spread and increasing ability to recognize its presence clinically have made endometriosis a condition of general medical interest.[9, 11, 12, 14, 19, 22, 23] Among 140,716 histologic diagnoses made by the pathology department of the University of Michigan during the ten-year period, 1934 to 1944, endometriosis was noted in 848 patients (0.60 per cent), compared to 10 cases in 14,397 diagnoses (0.06 per cent) made in this department in the twenty-year period, 1895 to 1915 (Table I). These histologic values are obviously considerably lower than the actual incidence. Since the totals include both sexes and all ages, the percentages are far lower than those based on series of abdominal and pelvic operations.[1, 6, 10, 12, 16, 20] It has been estimated from comparative statistical reports[16, 17, 21] that endometriosis exists in 10 to 22 per cent of all patients requiring gynecologic abdominal operations and in 8 to 15 per cent of all women during active menstrual life.

The intestinal tract is a highly significant extragenital location for endometriosis. In the material studied this site was involved in 35 patients (4.13 per cent); the appendix in 25 (2.95 per cent), the ileum in 1 (0.12 per cent), and the rectosigmoid in 9 (1.06 per cent) (Table II).

Occurrence in the small intestine usually is indicated by adhesions of the terminal ileum to pelvic structures with endometriosis of the loops of small bowel. The extramucosal invasion occasionally develops to the point of obstruction, which is the usual reason for the referral of these patients to a surgical service.[8, 18] Resection and anastomosis often effect immediate relief, but verification by a frozen section and castration, surgical or otherwise as previously discussed with the patient, are necessary if recurrence is to be obviated. Unfortunately, these patients have usually experienced many operations because of the adhesions from endometrial infiltrations and from repeated therapeutic procedures. Several instances of this nature have been encountered in this surgery department since the beginning of this study. The patients had experienced multiple operations at different hospitals but biopsies either were not done or were not conclusive.

Appendical endometriosis is practically always coincidental with more prominent adnexal disease, although not infrequently the diagnosis of acute appendicitis is made in an instance of ruptured endometrial cyst, with or without appendical disease. Of the 20 extramural specimens in this study, however, 10 were unaccompanied by other abnormal tissue. Of the intramural patients, 3 had coexistent right ovarian endometriosis and 2 were without asso-

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TABLE I. OVER-ALL INCIDENCE

	COMPLETE DIAGNOSES	NO. OF CASES OF ENDOMETRIOSIS	PERCENTAGE INCIDENCE OF ENDOMETRIOSIS
University Hospital patients (1934 to 1944)	71,951	181	0.25
Specimens received from outside (1934 to 1944)	68,765	667	0.97
Total, 10 year period (1934 to 1944)	140,716	848	0.60
Intramural and outside specimens (20 year period, 1895 to 1915)	14,397	10	0.06

ciated endometriosis, but all 5 had significant pelvic disease of some sort. Appendectomy, among other operations, is a frequent experience of the patient with endometriosis, without relief of symptoms. Cattell and Peacock[4] have described the worth of considering ruptured endometrial cyst in the differential diagnosis of acute appendicitis in female patients of appropriate age.

It is reported that the rectosigmoid is affected in 5[13] to 40 per cent[12] of patients with endometriosis, with an average of 25 per cent. Thus it is estimated[2, 12] that 2 to 4 per cent of all women (25 per cent of 8 to 15 per cent) during active menstrual life have rectosigmoidal invasion of some degree. This lesion may assume major diagnostic and therapeutic significance, for occasionally malignant disease is closely simulated and radical treatment for supposed carcinoma may ensue. Experiences of others with this difficult diagnosis[3, 5, 15] and its undesirable sequelae[2, 7] have been related. Of the 9 patients in this study, 3 were preoperatively considered to have carcinoma and were partially or completely treated on that basis. The excised specimen (831-LAT) of the first patient, upon whom the first stage of a Paul-Mikulicz procedure had been done elsewhere, was sent to this pathology department. The second patient (No. 230782) was referred to this surgery service, a loop colostomy having been performed elsewhere for supposed carcinoma of the rectum, with a request from her physician for resection of the lower segment. Histologic examination of the specimen from the first patient and exploration with biopsy of the second patient revealed endometriosis in each instance and further radical treatment was obviated.

The third patient (No. 381809), a 44-year-old, nongravid, married woman, was admitted to this surgery service complaining of persistent rhythmic abdominal pain, constipation and dyschesia enhanced by the menses. Appendectomy, left ovarian cystectomy, and uterine suspension had been done elsewhere five years previously for the same complaints. Rectal examinations, sigmoidos-

TABLE II. ENDOMETRIOSIS OF INTESTINAL TRACT

	ALL LOCATIONS	INTESTINAL TRACT			
		APPENDIX	ILEUM	RECTOSIGMOID	TOTAL
Intramural	181	5	0	6	11
Outside	667	20	1	3	24
Total	848	25	1	9	35
Percentage	100	2.95	0.12	1.06	4.13

copies, and biopsies revealed only chronic colitis. A roentgenograph following a barium enema disclosed a constriction of the sigmoid of "undetermined etiology." The reader's attention is called to the roentgenographic pattern so typical of that seen in carcinoma of the sigmoid colon (Fig. 1). At exploration an extensively adherent mass, which was higher than sigmoidoscopic range and the inflammatory nature of which defied safe excision for biopsy, was observed binding a loop of colon to the uterus and pelvic walls. A loop colostomy was effected at this time. After additional studies of the distal segment remained

Fig. 1.—Photograph of "barium enema" roentgenograph. Note the constriction in the sigmoid colon. (From Hodges, The Gastro-Intestinal Tract: A Handbook of Roentgen Diagnosis, The Year Book Publishers, Inc.)

inconclusive and therapeutic irradiation had been administered to the pelvis, a combined abdominoperineal resection was completed six months after the colostomy was done. The long constricted and inflamed mass of bowel failed to disclose a mucosal lesion, and microscopic examination revealed endometriosis of the sigmoid wall (Fig. 2).

Endometriosis simulates malignancy, not infrequently coexists with malignancy, and the ectopic cells themselves may undergo malignant degeneration.

There are accounts in the literature of carcinoma arising in endometrial tissue in the ovary[5] and colon,[11, 17] and also of a spindle-cell sarcoma[12] originating in ectopic stromal cells in the rectum. Although in this series 2 patients appeared to have adenocarcinoma arising in ectopic endometrium, evidence excluding coexistence was not convincing.

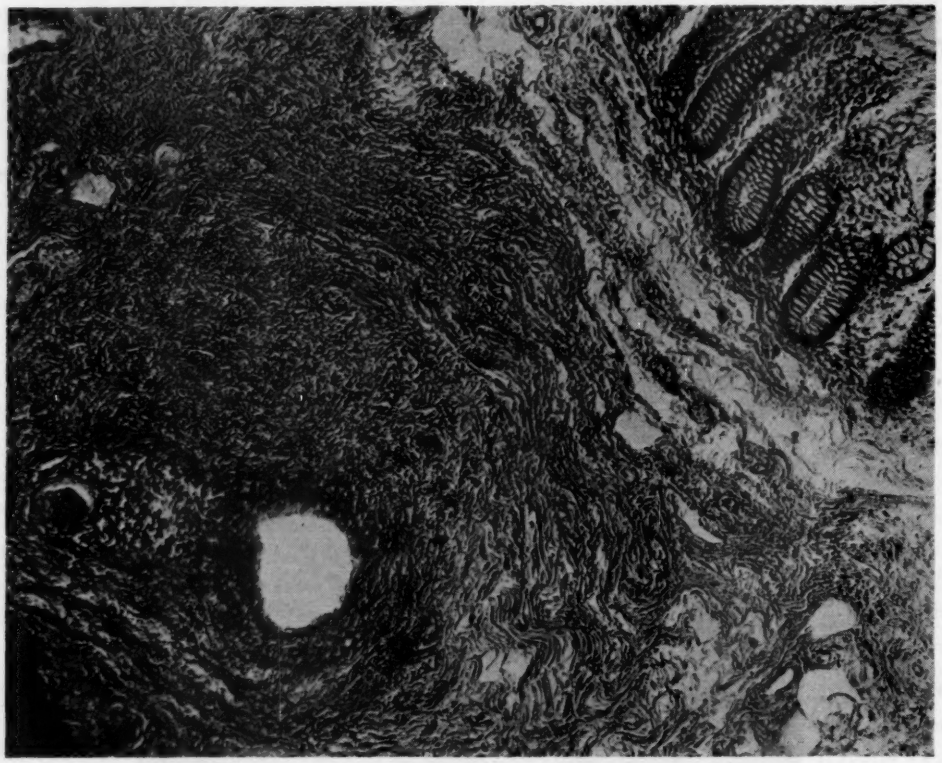

Fig. 2.—Photomicrograph of endometrial gland in the wall of the sigmoid colon. This is one part of a section that was heavily infiltrated with endometrial tissue. (×64.)

SUMMARY

The increased recognition of endometriosis and its extragenital manifestations in the past ten years have characterized it as a general medical problem. What was once chiefly of interest to the pathologist and the gynecologist now engages the practical concern of the internist, urologist, and general surgeon. Not the least of these clinical manifestations is the infiltration of endometrial tissue into the intestinal tract, particularly when the qualities of malignant invasion are simulated in the rectosigmoid. The paucity of pathognomonic signs of endometriosis and its frequent occurrence as a coexistent lesion of lesser importance preclude a satisfactory percentage of correct preoperative diagnoses. However, we are obliged to keep this entity in mind in women in active menstrual life who present uncertain intestinal complaints. Even then histologic examination will often remain the only certain means of confirming the diagnosis and thus obviate unnecessary operative intervention.

REFERENCES

1. Bockus, H. L.: Gastro-Enterology, Vol. 2, Philadelphia, 1944, W. B. Saunders Company, p. 789.
2. Bunch, G. H.: South. Med. & Surg. **105**: 313, 1943.
3. Cattell, R. B.: New England J. Med. **217**: 9, 1937.
4. Cattell, R. B., and Peacock, E. G.: Lahey Clin. Bull. **3**: 130, 1943.
5. Cattell, R. B., and Swinton, N. W.: New England J. Med. **214**: 341, 1936.
6. Counsellor, V. S., Masson, J. C., and Waugh, J. M.: Proc. Staff Meet., Mayo Clin. **15**: 792, 1940.
7. Dukes, C. E.: Proc. Roy. Soc. Med. **31**: 693, 1938.
8. Glenn, P. M., and Thornton, J. J.: J. A. M. A. **115**: 520, 1940.
9. Goodall, J. R.: Ann. Surg. **120**: 891, 1944.
10. Haydon, G. B.: Am. J. Obst. & Gynec. **43**: 704, 1942.
11. Hosoi, K., and Meeker, L. H.: Arch. Surg. **18**: 63, 1929.
12. Jenkinson, E. L., and Brown, W. H.: J. A. M. A. **122**: 349, 1943.
13. Keene, F. E., and Kimbrough, R. A., Jr.: J. A. M. A. **95**: 1164, 1930.
14. Marshall, V. F.: J. Urol. **50**: 652, 1943.
15. Mayo, C. W., and Miller, J. M.: Surg., Gynec. & Obst. **70**: 136, 1940.
16. Meigs, J. V.: New England J. Med. **226**: 147, 1942.
17. von Mikulicz-Rädecki, F.: München. med. Wchnschr. **86**: 962, 1939.
18. Morrin, F. J.: Irish J. M. Sc., p. 207, 1942.
19. O'Conor, V. J., and Greenhill, J. P.: Surg., Gynec. & Obst. **80**: 113, 1945.
20. Sampson, J. A.: Am. J. Obst. & Gynec. **4**: 451, 1922.
21. Sanders, R. L.: SURGERY **13**: 224, 1943.
22. Schlicke, C. P.: J. A. M. A. **132**: 445, 1946.
23. Weller, C. V.: Am. J. Path. **11**: 281, 1935.

THE METHOD FOR DISSOLUTION OF COMMON DUCT STONES REMAINING AFTER OPERATION

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IT IS well known, as was emphasized by the late Lord Moynihan, that stones in the common bile duct may easily be overlooked during an operation. However, the frequency of this incident is not generally appreciated. Young[1] found that in post-mortem examinations in patients who had been operated upon for choledocholithiasis, stones had been left behind in 16.4 per cent of the cases. Brunning,[2] in Popper's Clinic, found that in 367 cases in which the common duct had been opened, stones had been overlooked in 20 per cent. At the Lahey Clinic[3] prior to 1926, the common duct was opened in 15 per cent of all patients operated upon for cholelithiasis, and stones were found in the duct in 8 per cent. Since 1926, the common duct was opened in 44 per cent of the cases, and stones were found in 18 per cent. One might conclude from these figures that previously stones were left behind in 10 per cent of the cases. Other statistics reveal even higher figures. Mayo[4] reported that post-mortem examinations in patients dying following operations for common duct stones revealed that stones had been left behind in one-third of the cases. The causes of death were cholangitis and septicemia, but rupture of the common duct also has been reported. It appears to be a fact that stones are left behind in 16 to 25 per cent of all patients operated upon for choledocholithiasis, even by the most experienced surgeons.

It is easy to understand, therefore, that an imperfect operation may account for recurrent symptoms in a considerable number of cases (50 per cent), according to recent statistics of the Kirschner Clinic.

Two factors which cause stones to be overlooked are: (1) Stones in the ampulla can be so deeply embedded in crypts or ulcerations that they are actually inaccessible through the routine supraduodenal incision. Even a large sound may slide past such a stone and pass easily through the papilla. When indurated pancreatic tissue surrounds the ampulla, even careful palpation around a sound introduced through the papilla is not conclusive. (2) During attacks of biliary colic and vomiting, stones may be forced upward into the intrahepatic ducts. Later, they may descend into the common duct.

Retroduodenal or transduodenal exposure of the papilla are operations which decrease the probability of missing common duct stones. But such operations have a relatively high mortality (up to 20 per cent) and most surgeons are reluctant to use them in poor-risk patients. The difficulty of dealing with stones in the ampulla is emphasized by the fact that some surgeons (Finsterer and others) have even recommended leaving stones which are difficult to remove and performing a short-circuiting operation (choledochoduodenostomy). Such a procedure, however, has not been widely accepted.

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Two technics have been developed to improve the results in operations for choledocholithiasis: Mirizzi's method of cholangiography during the operation, and Pribram's method[5] for the postoperative dissolution of gallstones remaining in the common duct under cholangiographic control. Cholangiography during the operation enables one to discover stones in the common duct which otherwise might be missed, but even with this method it is difficult to be certain that all stones have been removed. In a case in which multiple stones have been removed, even though cholangiography has been carried out during the operation, the *surgeon should never omit drainage of the common bile duct* which provides opportunity for further cholangiographic studies in the postoperative period.

The scaffolding of the usual gallstone is made up of cholesterol, which is soluble in ether. By dissolving the scaffolding, ether disrupts the structure of a stone, causing it to crumble into a mud, the particles of which can easily pass through the papilla. The *ether method,* therefore, is effective only against stones containing cholesterol.

Practically all stones containing large amounts of cholesterol are formed in the gall bladder. Such stones may pass into the common duct either through the cystic duct or by way of an internal biliary fistula.

The usual attack of gallstone colic indicates that a *stone in the gall bladder has moved from the insensitive fundus to the opening of the cystic ducts,* the most sensitive area in the whole biliary duct system. A stone in the opening of the cystic duct causes the muscular wall in the collum-cystic area to contract in a painful spasm. During such an attack the stone may pass through the cystic duct into the common duct, or may slip back into the fundus. In either case the biliary colic is relieved. On the other hand, a *stone may pass through the papilla without causing pain.* The papilla is much less sensitive than the collum-systic area. These statements are based on the results of experiments which were carried out over a period of many years.

The cystic duct is the usual pathway for stones which move from the gall bladder into the common duct. In some instances a large stone may pass directly into the common duct through an internal biliary fistula between the gall bladder and the duct. It is well known that in other instances gallstones may pass directly into the duodenum or colon.

Stones may form within the common duct in the presence of stasis of bile and cholangitis secondary to obstruction at the papilla. In most instances such stones are pigment calculi containing relatively small amounts of cholesterol. A stone originating in the gall bladder may lodge at the terminal portion of the bile duct and cause stasis of bile. Pigment concretions then may form in the stagnant bile above the obstruction and such stones may extend high up into the intrahepatic ducts. Foreign bodies such as a rubber tube favor such precipitations. Incrustation of rubber tubes lying within a bile duct occurs regularly.

Among the yellow races, on the other hand, conditions of stone formation are quite different. Among Chinese and Japanese, gall bladder stones are extremely rare, whereas the great majority of stones are pigment stones and are

formed within the bile ducts. Such a "Chinese stone" which was formed primarily within the common duct has been analyzed by Dr. Wong (Digby) with the findings as listed in Table I.

TABLE I

	PER CENT
Bilirubin and biliverdin	93.12
Cholesterol	1.64
Calcium	1.20
Phosphate	2.10

In orientals, therefore, stones may form in the bile duct while the gall bladder remains normal. In patients with obstructive jaundice caused by stones in the ampulla, the unaffected gall bladder is commonly greatly enlarged. Courvoisier's law, therefore, is useless in the Far East.

The process of crumbling down of the stones through dissolution of the cholesterol scaffolding necessarily takes some time, especially because only small amounts of ether can be used at the same time. This can be shown experimentally by putting some cholesterol-containing stones in a test tube and mixing them with ether. The process of dissolution of cholesterol out of the stones can be demonstrated by the appearance of the white cholesterol needles crystallizing on the wall of the test tube when the ether evaporates (Fig. 1). This can be observed very soon. However, it might take hours before the stones are transformed into a brown mud of pigment. Enlightening experiments concerning the dissolution of gallstones in the gall bladders of dogs by means of ether injections have been carried out by A. B. Raffle. Only in rare cases may we expect success within a few days.

It is of considerable practical importance to know that there is a very good method of dealing with remaining common duct stones in the postoperative period under cholangiographic control. The results of Pribram's ether method have meanwhile been confirmed by many observers.[7-12] With that knowledge, one is not compelled to force the issue of freeing the papilla on the operating table. In my own statistics this has caused the mortality rate in poor-risk cases to drop to 3 per cent. In surveying fifty-one cases in which the ether method was used for the postoperative dissolution of gallstones remaining in the bile duct, I have found no failures and I have not found it necessary to perform a secondary operation.* Since other surgeons who have used the ether method have had only partial success or no success at all, there must be a difference in technique to account for the variance in the results.

The first consideration is that of the solvent. Ether is used for this purpose. Although chloroform and acetone are better chemical solvents for cholesterol, they should not be used. Acetone is badly tolerated by the patient, and I have seen ulcerations in the duodenum with serious hemorrhage following the use of chloroform. One such patient nearly died. Ether, on the other hand, has been used clinically with satisfactory results. In experiments on dogs,

*One patient was operated upon by another surgeon for recurrent attacks three years later, but I have been unable to obtain the operation report.

Raffle found that ether produced "no evidence in any of the animals of inflammatory reaction about the bladder, ducts or liver sufficiently severe to make a permanent change in the tissue."

In some instances it is advantageous to mix a small amount of alcohol with the ether. This raises the boiling point of the fluid so that it exerts less pressure when it is injected. But the solubility of cholesterol in an ether-alcohol mixture is less than in ether alone, so the mixture should not contain more than 10 to 20 per cent of alcohol.

The opinion has been expressed that the success of the ether method is not due to dissolution of the stone, but that the boiling ether blasts the way open through the papilla. This is certainly wrong. However, this idea apparently has induced some surgeons to use force while injecting as much as 5 c.c. of ether—certainly not to the liking of the patient, and probably without success, since such forced injections are regularly followed by a violent spasm of the sphincter muscle.

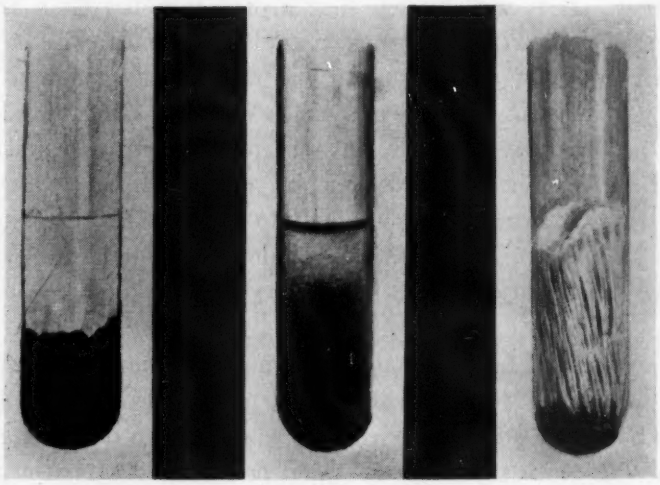

Fig. 1.—Experimental dissolution of gallstones in vitro.

Flushing the common duct with saline solution in an attempt to open the papilla by means of hydraulic pressure was carried out unsuccessfully by H. Kehr more than fifty years ago. The patients resented the pressure and the papilla did not open.

Increased pressure within the common bile duct causes the patient to experience a very unpleasant sensation. Moreover, if mechanical pressure were effective, one would expect a sudden and dramatic effect, but such results do not occur.

In some of my cases the process of dissolution of stones could be followed in a series of cholangiograms, showing the gradual diminishing size of the obstructing stones, the increasing patency of the papilla, and the passing of larger amounts of lipiodol into the duodenum. X-ray control is an important part of the postoperative treatment.

The use of the T tube for drainage of the common bile duct merits discussion. The T tube is not suitable for use with the ether technique for dissolution of stones. When ether is injected through such a tube much of it evaporates upward into the liver instead of reaching the stones. Ether penetrating into the intrahepatic ducts produces an unpleasant sensation of pressure and nausea and may even produce vomiting.

Also, use of the T tube deprives us of a very important sign in cholangiography. The intrahepatic ducts should *not fill at all* when the papilla is patent. When injecting lipiodol slowly through a tube which points only downward, the opaque liquid should pass directly into the duodenum. Filling of the intrahepatic ducts, provided correct technique is used, is always a sign of a certain back pressure suggesting *incomplete patency of the papilla* (stone or spasm). I believe that the use of the T tube is one of the main factors in the failure of the ether method and also in the failure to secure satisfactory cholangiograms.

Moreover, removal of the T tube may in some cases cause a tearing of the wall of the duct. It is well known that injury inflicted on a fresh scar may stimulate excessive growth of fibrous tissue. This may well account for an excessive cicatrization of the wound in the wall of the common duct and the later tendency to shrink. In recent times an increasing number of benign strictures as postoperative sequels have been reported. It must be admitted that many of those strictures probably are due to direct injury of the duct during operation. However, it is difficult to believe that injuries should take place on such an amazing scale. It is possible that some of the strictures result from excessive cicatrization following injury to the duct caused by removal of a T tube.

For these reasons I believe that in common duct surgery the T tube should not be used. A simple tube or catheter is preferable, and a catheter with a double lumen has some advantages. Even when such a drain is stitched watertight into the duct with silk sutures, it can be removed after ten to twelve days without the slightest difficulties. It may also be reintroduced after it has been withdrawn.

Confidence in the effectiveness of the ether method for postoperative dissolution of remaining common duct stones should not deter the surgeon from carefully removing all accessible stones at the time of operation. It does, however, eliminate the necessity of *forcing* the papilla. There is no harm in trying to pass the papilla with sounds or bougies of increasing caliber as long as the procedure is carried out with the greatest gentleness. But forcible dilatation is a risky procedure because of the danger of making a false passage. This takes place much more often than is generally realized, and penetration into the surrounding pancreatic tissue is especially frequent. I have interested some pathologists in this question, and they have paid especial attention to the possibility of a false passage in patients who have come to necropsy after common duct surgery. They have found that it is a frequent incident and that in many instances the operating surgeon has been unaware of the accident.

The Lahey Clinic (R. Adams[14]) has reported three cases showing fatal ascending infection with gas bacilli following forcible dilatation of the papilla.

Furthermore, forcible dilatation may cause a crack or tearing of the papilla which might later cause stricture through scarring.

In badly infected patients with prolonged jaundice and danger of cholemic bleeding, all forcible attempts should be avoided. Not only is forcible dilatation of the papilla dangerous, but it is pointless. The passage of a sound through the papilla into the duodenum gives no assurance that all stones have been removed. Postoperative cholangiograms have given ample evidence of that.

In all cases of prolonged obstructive jaundice, there is more or less liver damage. The hepatic injury is even more serious in the presence of cholangitis. Therefore, the use of general anesthesia and the barbiturates should be avoided or restricted as much as possible. A patient with severe liver damage might pass from the state of anesthesia into hepatic coma. Spinal anesthesia, with the addition of gas-oxygen when necessary, has proved to be the least harmful method in such cases and can be recommended.

For twenty years we have favored the use of the subcostal incision.[13] Wide exposure, immediate access to the operative field, the ease with which neighboring structures (duodenum and right colonic flexure) can be excluded from the field, and the nonexistence of postoperative hernia even in badly infected wounds are definite advantages which have been confirmed by all surgeons who have used the incision.

After clear exposure of the structures by sharp dissection of adhesions, if necessary, the gall bladder is emptied by aspiration and the cystic duct is carefully dissected and divided between two silk ligatures. *No clamps are ever used on the cystic duct.* The gall bladder is opened and electrocoagulated. The liver bed of the gall bladder should be completely dry.

The common duct then is opened about halfway between the normal emptying place of the cystic duct and the duodenum. The opening should not be too near the duodenum for two reasons. First, a small amount of leakage in the supra-ampullary region might disturb the clearness of the postoperative cholangiogram, and, second, it is easier to maintain the choledochostomy tube in position when some distal stump of the common duct is present. Exploration of the common duct through a split cystic duct is not to be recommended. The cystic duct often runs parallel to the common duct for a considerable distance and may empty rather low, so that the upper portion of the choledochus is difficult to explore. It is good practice to empty the common duct by aspiration before it is opened. This makes stones more easily visible, and they are less likely to slip upward into the hepatic ducts during manipulation.

With the duct opened, all accessible stones are removed. A scoop or sound is passed downward to the papilla, and the ampulla is carefully palpated around the sound. Many stones can be discovered in this way. However, in the presence of a swollen and indurated pancreas head, the success of detecting stones by palpation is limited. One may mistake indurated lobules for stones and try vainly to extricate them with a scoop.

One is pleased when the sound passes easily through the papilla into the duodenum. However, we need not feel uneasy when this does not occur. We may terminate the operation at that point with safety. Immovable stones in the ampulla are certainly a challenge, and it injures the pride of the surgeon to fail in his attempt to remove all stones and secure free passage through the papilla at the time of operation. But admitting that we are not successful in all cases, it is a relief to know that there is a method of dealing with these stones safely in the postoperative period.

A double-barreled catheter with two side holes is then introduced downward into the common duct until the tip touches the stones in the ampulla. The size of the tube is determined by the diameter of the common duct, a catheter being selected which will allow free passage of bile from the liver.

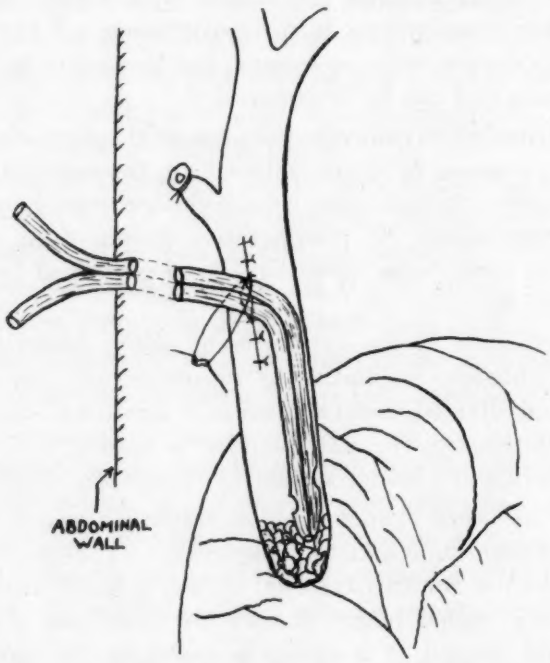

Fig. 2.—The double-barreled catheter in place in the common bile duct.

The wall of the common duct is then closed around the catheter with five silk sutures, several of them being tied around the tube in order to fix it in position. Traction on the catheter should not displace it. Watertight closure of the common duct must be attained, and this should be tested by the injection of saline solution. Leakage might interfere with the clearness of the cholangiogram, and it also hinders the proper placing of ether upon the stones. The suture line is reinforced by a layer of the hepatoduodenal ligament, or by a serosal flap from the area of the cystic duct.

If the liver is enlarged, the tube is brought out through a small stab wound in the most suitable position. For safety another rubber tube may be inserted beside the choledochostomy tube and left in place for forty-eight hours if it

seems necessary. The common duct tube is fixed by means of a safety pin and is plastered firmly to the skin.

On the fifth day after operation, if recovery has been uneventful, the first cholangiogram is made. The patient lies in the supine position, slightly on the right side. All plasters are removed, and the tube is held firmly in position by an assistant. Fifteen to twenty cubic centimeters of warm lipiodol are injected slowly, and two to four pictures are taken at intervals of five to ten minutes. The oily solution is preferred, since aqueous solutions give precipitations when mixed with bile.

Correct interpretation of cholangiograms requires some experience. In case the ampulla is free of stones and the papilla is open, the opaque liquid passes directly into the duodenum and the intrahepatic ducts do not fill at all, provided the injection is carried out slowly. Any filling of the intrahepatic ducts suggests some *back pressure* which might, of course, be due to spasm. Actual conditions are revealed clearly in a series of pictures. In case there is still some suspicion of a sphincter spasm it can be released by intravenous injection of ½ to 1 mg. atropine sulfate or by inhalation of amyl nitrite.[12]

When there is evidence of stones, the ether treatment is initiated. The treatment is best carried out in the morning with the patient fasting in order to diminish bile secretion. The bile duct is emptied by aspiration of bile through the tube. Ether is then injected drop by drop and the patient is asked to signify the point at which he feels pressure. Then ether is reaspirated and the procedure is repeated several times within the limits of tolerable pressure, as indicated by the patient. It has proved helpful to use a *double-barreled catheter* (see Fig. 2), one tube providing decompression by allowing immediate evaporation of ether during injection. Undue discomfort resulting from pressure can thus be almost entirely avoided. The flush is terminated by injecting 5 to 10 c.c. of warm paraffin or olive oil, and the tube is then closed for several hours. The patient may reopen it when he feels increasing pressure.

The whole procedure can be repeated several times a day and is continued for at least a week. After that time another cholangiogram is made.

The gradual crumbling of the stones, the diminution of introductal pressure, and the opening of the papilla permit injected saline solution to pass into the duodenum, so that the amount returning through the drainage tube diminishes until the return drainage ceases completely. Eventually the tube can be passed easily through the open papilla into the duodenum. It is interesting to note that in no instance did the patient feel any pain or even the slightest awareness of an unpleasant sensation during this procedure. This fact can be taken as further proof for the thesis, which I have always maintained, that *the common attack of colic is caused by a stone passing through the cystic duct or touching the collum-cysticus area, and not as a result of a stone passing through the papilla.*

The time required for the dissolution of stones varies greatly and depends upon several factors. It depends upon the degree of access of ether to the stones. Patients with an enlarged common duct feel the pressure much less than patients with a small duct. Greater amounts of ether can, therefore, be applied in patients with dilated ducts.

Abundant drainage of bile from the liver dilutes the ether and may interfere with the access of ether to the stones. Fasting and restriction of fluid intake, therefore, are helpful.

The more frequently the injection is carried out, presumably, the shorter will be the time for successful dissolution of the stones. The time required for crumbling the stones depends also on the chemical character of the calculi. Stones with a high cholesterol content are easier to fragment than those with

Fig. 3*A*.

Fig. 3, *A*, *B*, and *C*.—Cholangiograms showing the successful dissolution of common duct stones by the ether method.

a high calcium-pigment content. The accessible surface of the stones is also important. Calculi hidden in crypts or in ulcerations in the ampulla are less accessible than a mass of small stones filling the ampulla.

In many instances I have used novocain, atropine, amyl nitrite, and other drugs in an attempt to relax a presumed spasm of the sphincter muscle. No harm is done in trying them, but I have seen no convincing evidence that they shorten the time required for the elimination of stones.

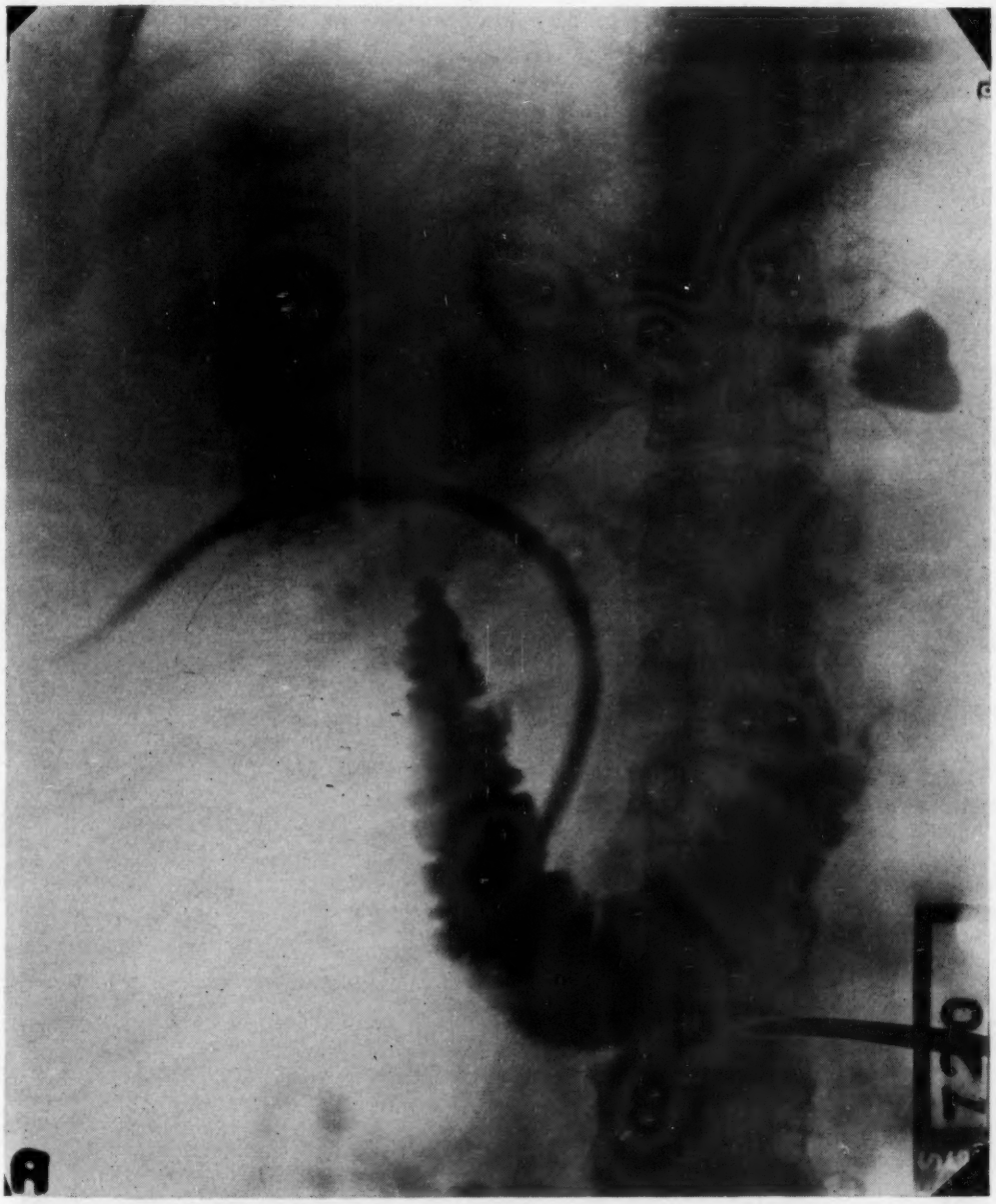

Fig. 3*B*. *(For legend see opposite page.)*

In many instances patients have been dismissed from the hospital after fourteen days with the choledochostomy tubes in place and have been treated as outpatients. Safe fixation of the tube to the skin is important, but if the tube comes out it can easily be replaced provided it is done immediately. A patient who was a physician carried out the treatment himself at his home and returned only for the final cholangiogram and to be congratulated for his success.

The time required for the dissolution of calculi varies from one to six weeks. In two patients I was on the verge of undertaking a secondary operation before

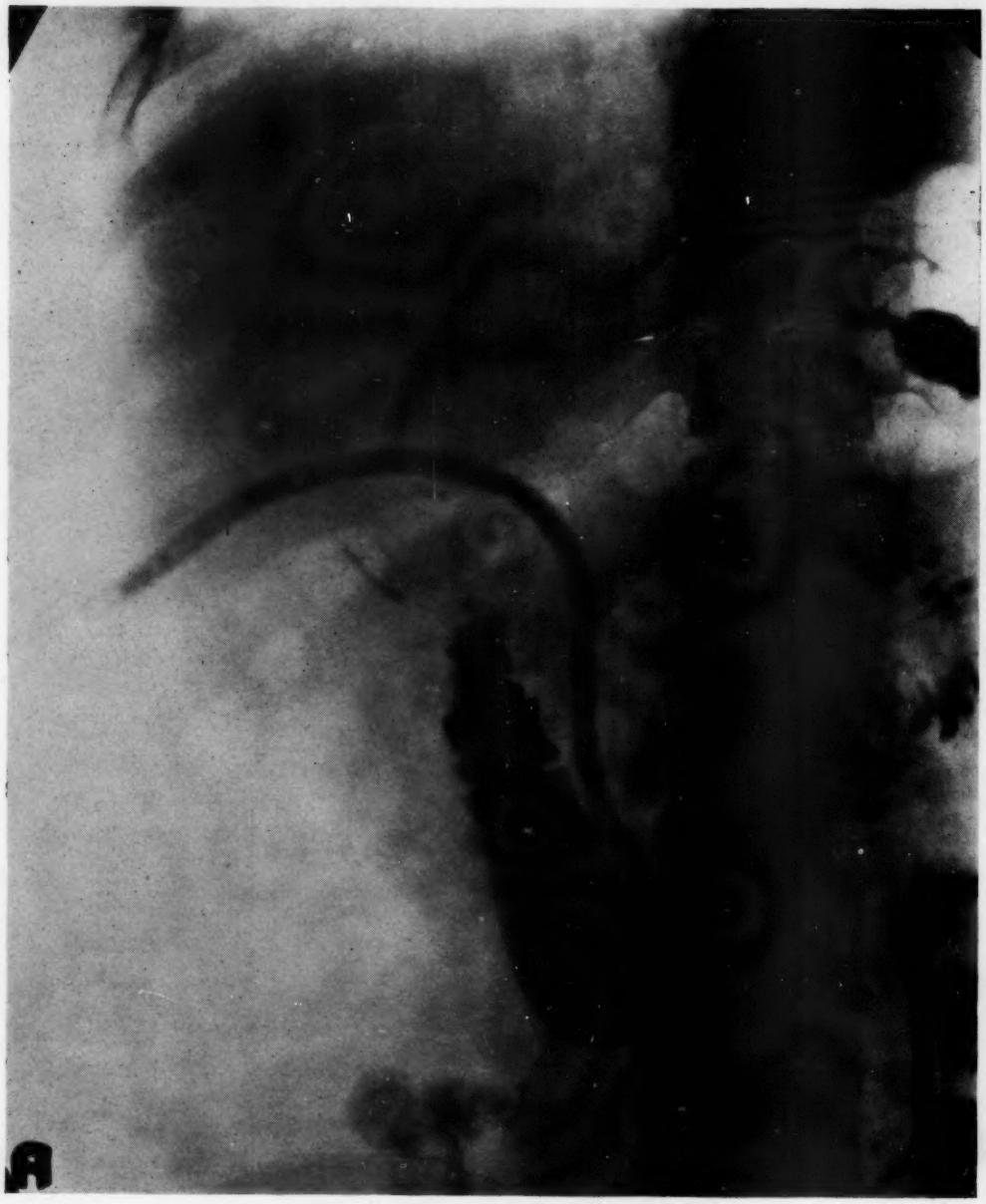

Fig. 3C. *(For legend see page 814.)*

the ether method was finally successful. In one patient, 70 years of age, the papilla was still obstructed after five weeks of treatment. Blood oozing from the tube suggested a malignant growth and secondary operation was contemplated. A cold which the patient developed necessitated postponement of the scheduled operation for one week, during which time the ether treatment was continued. A final cholangiogram on the day before the operation was to have been performed revealed that the papilla was completely free of stones. Three years later the patient was reported perfectly well.

I have had to treat several patients with external biliary fistulas in whom common duct stones had been overlooked at operation. The general condition of such patients is sometimes poor. The appetite and digestion are disturbed and the patients are dehydrated because of loss of fluid through the fistula. The patient's condition sometimes deteriorates very rapidly, but a surgeon cannot lightly advise a second operation early in the postoperative course and maintain the hope that the stone will eventually pass spontaneously. There can be no doubt that the risk of the second operation is considerable. In such cases the ether method offers the possibility of safe treatment, and in the cases in which I have used it I have had no failures.

Cholangiography is first performed to confirm the presence of stones as the cause of the obstruction, and the ether method is then used. It has always been easy to introduce a rubber drain into the fistula, and the catheter finds its way into the common duct. In one case in which the external biliary fistula had persisted for three and one-half months, the ampulla was emptied after treatment over a period of one week, and the fistula closed two days after removal of the drain.

The accompanying cholangiograms (Fig. 3, *A* to *C*), of recent date, demonstrate the results of the ether method of dissolution of remaining common duct stones in a 54-year-old woman with an obstructive jaundice of three months' duration. For three weeks there was no success, and the skeptical attending physician urged a second operation. Only on the twenty-fifth day did the cholangiogram show disappearance of the obstructing stones and a complete patency of the papilla. The final cholangiogram shows how easily the catheter could be passed through the papilla.

These cholangiograms are perhaps dramatic, but the method is not. It is a slow, conservative method which requires patience and time. Its greatest advantage is that it is entirely safe and harmless.

REFERENCES

1. Young: Quoted by F. Dehmel, Klin. Wchnschr. **15**: 649, 1936.
2. Brunning: Deutsche Med. Wchnschr. **38**: 1543, 1912.
3. Quoted in Boyce, F. F.: Ann. Surg. **109**: 353, 1939.
4. Mayo, W.: Lancet **1**: 1299, 1923.
5. Pribram, B. O. C.: Deutsche Med. Wchnschr. **58**: 1167, 1932.
   Idem: Bull. Soc. nat. Chir. **59**: 1264, 1933.
   Idem: Neue deutsche Klin., Berlin, 1934.
   Idem: Schweiz. med. Wchnschr. **65**: 89, 1935.
   Idem: Surg., Gynec. & Obst. **60**: 55, 1935.
   Idem: Zentralbl. f. Chir. **63**: 1506, 1936.

Idem: Proc. Internat. Congress, Union Therapeutique, Berne, 1937.
Idem: Proc. Internat. Congress, Hepatic Insufficiency, Vichy, 1937.
Idem: Lancet, p. 131, 1939.
Idem: Bull. Université de l'Aurore, Shanghai, Nos. 1 and 2, 1945.
6. Raffle, A. B.: Am. J. Surg. **52**: 65-69, 1941.
7. Basset, M. E.: Bull. Soc. Int. de Chir., Paris **60**: 3b, 1934.
8. Best, P. R.: Surg., Gynec. & Obst. **66**: 1040-1046, 1938.
9. Erkes, F.: Zentralbl. f. Chir. **61**: 2272, 1934.
10. Gertz, T. C.: Acta chir. Scandinav. **90**: 249-263, 1944.
11. Thorek, M.: Cir. y cirujanos **11**: 563-576, 1943.
12. (a) Walters, W.: Proc. Staff Meet., Mayo Clin. **12**: 260-262, 1937.
(b) Walters, W., and Snell, A. M.: Diseases of the Gallbladder and Bile Ducts, Philadelphia, 1940, W. B. Saunders Company.
13. Pribram, B. O. C.: Deutsche Ztschr. f. Chir. **225**: 446, 1930.
14. Lahey Clinic, Ralph Adams: S. Clin. North America, p. 551, 1944.

BRACKETT OPERATION FOR UNUNITED FRACTURE OF THE NECK OF THE FEMUR

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THE procedure of efficient closed reduction in fresh fractures of the neck of the femur, such as the Whitman or Leadbetter methods, with the application of properly placed internal fixation, developed during recent years, has increased the percentage of fractures in which union occurs to 72.9 per cent, according to statistics of the Fracture Committee of the American Academy of Orthopaedic Surgeons. This is the percentage of union obtained only by internal fixation; a study of all methods of treatment of fractured hips in the country as a whole would surely show a much higher percentage of nonunion.[1] The numerous methods of treatment and the varying results reported in current literature attest the fact that though results are better than those previous to the period of internal fixation the problem is as yet not completely solved.

Selection of proper treatment in those many cases in which nonunion persists after treatment is a problem. This is rendered somewhat more difficult by the paucity of reports in the literature dealing with the end results of significantly large series of cases in which repair procedures have been used. In a previous paper Rowe and Ghormley[2] reported data on the Brackett operations at the Mayo Clinic through 1942 and described briefly the three general classes of procedures for correction of nonunion of the neck of the femur. They gave especial attention to indications and limits of application of these procedures. It was pointed out at that time that the use of one of the reconstructive procedures was favored over osteotomy, whenever the condition of the patient warranted it, because better mechanical function was attained. That opinion is still held and the present report is being made to summarize data concerning, and to evaluate the results of, all the Brackett operations at the Mayo Clinic through 1945. It includes additional follow-up information and re-evaluation of results in those cases reported by Bickel and Ghormley[3] in 1941 and in the series reported by Rowe and Ghormley in 1944.

In twenty-six years, from 1920 to 1945 inclusive, the Brackett (or modified Brackett) operation was performed in seventy-one cases (Table I). More than 50 per cent of these operations were performed in the last three years. Twenty-three (32 per cent) of these seventy-one patients had undergone at least one operation elsewhere and two of these twenty-three had undergone two operations elsewhere.

Of the seventy-one patients, forty-five were women and twenty-six were men. The average age at the time of operation was 53.7 years. The range

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TABLE I. BRACKETT OPERATIONS BY YEARS*

YEAR	OPERATIONS
1920	1
1925	1
1926	1
1928	1
1930	1
1934	1
1936	1
1937	4
1938	5
1939	1
1940	2
1941	5
1942	9
1943	16
1944	11
1945	11
Total	71

*Includes modified Brackett operation.

was from 7 to 77 years. The average duration of the nonunion at the time of operation was 18.2 months, with a range of from three months to ninety-six months.

TECHNIQUE

Brackett's[4] original technique was described in part as follows:

The tensor fasciae femoris and gluteus medius are separated, the muscle attachments on the outside of the trochanter are removed subperiosteally, or with a thin bone attachment, and the top of the trochanter removed so as to save the attachment of the gluteus minimus and pyriformis. These muscles are then all turned backwards and upwards, and the upper and anterior portion of the capsule exposed, to the edge of the acetabulum. The capsule is opened longitudinally to its fibers, on the upper portion of its anterior surface, saving the attachment of the Y ligament if possible, but which, however, cannot always be done.

The capsule above the opening is then detached from the femur and retracted outward and backward; the trochanter cut off just below the level of the upper edge of the head, the inner portion rounded to correspond to the curve of a 1½ inches to 2 inches radius, saving the anterior and inner cortex. The outer portion is either cut off obliquely, or a wedge taken out, near the outer surface, allowing the outer cortex to be pushed inward. The free surface of the head is thoroughly freshened, covering this area, so as to make a corresponding curve, to the rounded top of the trochanter. In abduction of the leg, the convex surface which has been fashioned on the trochanter, is brought directly into the concaved head, and in this position is firmly held against it. In this way the femoral head with its freshened surface is placed directly on the freshened cancellar surface of the trochanter—an ideal condition for the vitalizing union of the poorly nourished fragment. The head is not placed directly on the top of the trochanter, for this would not allow the best position in the acetabulum, but on the inner and upper sides, which gives to it a somewhat oblique angle, partly resembling its normal direction, but without the normal neck. . . . [Then after closure of the capsule] the attachments of the gluteus medius and minimus, and pyriformis, are either secured to the outer side of the trochanter, or are inserted into the wedge-shaped depression, which has been made, in order to round off its upper and outer end.

Magnuson,[5] in 1932, described a modification in which, after preparation of the head of the femur, the trochanter and attached muscles were cut off at

an angle estimated to be the original angle of the neck of the femur; that is, the line of incision through the trochanter sloped downward and outward. "This incision, at the upper end, was started exactly at the base of the neck of the femur, leaving intact whatever portion of the neck remained attached to the shaft; the upper end of the shaft, with the remainder of the end of the neck, was then brought up into the incision and rounded off in the same curve which had been produced in hollowing out the head." After this newly modeled neck was levered into position in the head, the trochanter with its attached muscles was pulled downward to come into a position below and lateral to its normal position and the sharp, wedge-shaped lower end protruded beyond the shaft on the lower lateral border of the place from which it was removed. It was fixed in this new position by sutures passed through drill holes.

Thus, the Brackett operation, as modified, practically re-establishes the normal relations of the hip so that the muscular attachments are all in place and have a constant tendency to hold the upper end of the shaft firmly into the head. The operative technique employed in our cases resembled closely the Magnuson modification, but the method of internal fixation has varied among surgeons. It is significant that of the thirty-eight cases in which the operation was performed during 1943, 1944, and 1945, internal fixation, usually with one or more vitallium screws, was used in all but three cases. In the entire series internal fixation of some sort was used in fifty-five cases, or 77.5 per cent (Table II).

TABLE II. INTERNAL FIXATION AT TIME OF BRACKETT OPERATION

MEANS	CASES	PER CENT
Vitallium screws	44	80.0
Beef bone screws	4	7.3
Wire nail	3	5.5
Steel nail	2	3.6
Johannsen nail	1	1.8
Knowles pin	1	1.8
Total	55	100.0
SITE		
Head and shaft only	43	78.2
Trochanter, shaft and head	7	12.7
Trochanter and shaft	5	9.1
Total	55	100.0

RESULTS

One hospital death occurred in this series of seventy-one cases; the mortality rate, therefore, was 1.4 per cent. Death was attributed to staphylococcic bacteriemia secondary to infection of the wound, and the patient died six weeks after the operation, which was performed in 1938. Postoperative complications encountered in the series are summarized in Table III.

Postoperative hospitalization in these cases averaged eighty-nine days, the shortest being forty-eight days and the longest 252 days. In twenty-six cases in which definite information was available, the average time after operation when crutches could be discarded entirely was 33.3 weeks, with a range of from six weeks to seventy-five weeks.

TABLE III. POSTOPERATIVE COMPLICATIONS

COMPLICATION	CASES	PER CENT
Wound infection	3	4.2
Conditions requiring transfusions	17	23.9
Decubitus ulcer	2	2.8
Pulmonary infarct	1	1.4
Thrombophlebitis	1	1.4
Psychosis	1	1.4

In evaluation of the end results in these cases certain standards were adopted arbitrarily. The ability to walk without aid of a cane or crutches and the possession of a practical range of painless motion of the hip were selected as the criteria of the good result. A practical range of motion of the hip was considered to be that range of motion which allowed the patient to carry on normal activity without undue restriction or encumbrance. The ability to tie the shoe on the foot of the affected leg and to climb the stairs one foot ahead of the other in the normal manner were often used to determine the practical range of motion.

If the patient was able to get around with the help of a cane, and pain and limitation of motion of the hip were slight, the result was considered to be fair. If the patient derived no benefit from the operation or was worse after the operation than before, the result was classed as poor and considered a failure.

Eight of the seventy-one cases were discarded because follow-up observation was not adequate enough to enable us to evaluate the results finally. Therefore, sixty-three cases (88.7 per cent of the total) are left for analysis. The results are given in Table IV.

TABLE IV. END RESULTS OF 63 BRACKETT OR MODIFIED BRACKETT OPERATIONS

RESULT	CASES	PER CENT
Good	42	66.6
Fair	9	14.3
Poor	11	17.5
Death	1	1.6
Total	63	100.0

Evaluation of results for the entire series according to the method of internal fixation used is given in Table V. The increasing use of vitallium screws as the means of fixation of choice is obvious.

TABLE V. END RESULTS ACCORDING TO FIXATION USED

	PATIENTS		RESULTS, CASES			
MEANS	TOTAL	NOT TRACED	GOOD	FAIR	POOR	DEATH
Vitallium screws	44	2	31	4	7	0
No fixation	16	4	7	3	2	0
Beef bone screws	4	1	3	0	0	0
Wire nail	3	1	0	1	0	1
Steel nail	2	0	0	1	1	0
Johannsen nail	1	0	0	0	1	0
Knowles pin	1	0	1	0	0	0
Total	71	8	42	9	11	1

Review of the eleven cases in which treatment failed shows that in four cases slipping of the fragments, always of the head from the shaft, occurred after good position had been obtained at operation. In three cases typical aseptic necrosis of the head occurred and in two of them it was noted at operation that the head did not bleed very well. In another case, that of a woman 71 years old, roentgenograms made two years after surgical treatment showed nonunion. The head of the femur was markedly absorbed and the remainder devitalized. No further reconstruction was advised. One patient, aged 75 years at operation, did not stop using crutches before death from other causes occurred eighteen months after operation. In one case the checkup eighteen months after operation showed no union and at reoperation, when a Whitman reconstruction was performed, some bony union between the head of the femur

TABLE VI. RESULTS IN REPAIR OF UNUNITED FRACTURES OF THE HIP

AUTHOR	OPERATION	CASES	REPORTED RESULT		PER CENT FAVORABLE
			RESULT	CASES	
Colonna, 1939[6]	Colonna	40	Excellent Fair Poor Failure	24 (60.0%) 9 (22.5%) 2 (5.0%) 5 (12.5%)	82.5
Henderson, 1940[7]	Intra-articular osteosynthesis	67	Union Failure Death	46 19 2	68.6
Gallie and Lewis, 1940[8]	Smith-Petersen nail and graft	15	Union Failure Too early	6 1 8	Not evaluated
Magnuson, 1940[9]	Modified Brackett	41	Good Poor Death Other	28 6 2 5	68.3
Reich, 1941[10]	High oblique osteotomy	26	Good Failure Death	22 3 1	84.6
Campbell and Smith, 1941[11]	Trochanteric osteotomy	28	Good Fair Poor	14 (50.0%) 8 (29.0%) 6 (21.0%)	78.6
Henderson, 1941[12]	Extra-articular osteosynthesis	14	Excellent Good (union) Fair Failure Too early	8 2 1 2 1	78.6
Hermann, 1942[13]	Colonna Magnuson Bone graft Hibbs fusion McMurray	12 7 3 3 8	Good Good Good Good Good	8 4 3 2 5	66.7 57.1 100.0 66.7 62.5
Speed and McGehee, 1944[14]	Subtrochanteric osteotomy	38	65.00% could walk without support and had a good range of motion; little or no pain 89.46% favorable results		
Leadbetter, 1944[15]	Cervical-axial osteotomy	8	Solid union Clinical union	6 2	100.0
Stewart, 1945[16]	Subtrochanteric osteotomy	11	Good Fair Poor Failure	4 3 2 2	63.6

and the acetabulum was noted. Finally, one case was judged to be a failure because pain persisted after the operation.

COMMENT

The end results of various operative procedures that have been reported in the literature in the last few years are summarized in Table VI.[6-16] The criteria on which these end results have been judged may vary widely but it seems evident that, in the hands of experienced surgeons, in a large series of cases of nonunion of the neck of the femur, repaired by any one of the several procedures now being used, favorable results can be expected in from 60 to 80 per cent. Good or fair results were obtained in about 80 per cent of our entire series.

Although the Magnuson modification of the Brackett operation is a somewhat more complicated surgical procedure than, for instance, the osteotomy, it is still our opinion that the good results obtained by this operation are so much better than the good results obtained with other reconstructive procedures that its continued and increasing use is justified. The prerequisites are not as stringent as for bone grafting procedures and the modified Brackett operation is applicable in a large majority of cases of nonunion in which the head of the femur is viable. The operation should not be attempted, of course, in the presence of articular damage. Age in itself is not a criterion in the selection of cases. Twenty-seven of our seventy-one patients were in the sixth or seventh decade.

Since the predominant cause of failure was slipping of the shaft from the head, careful positioning at the time of operation must be emphasized; as much valgus as possible must be obtained and the fragments must be transfixed adequately. In only one case in this series was there a persistent abduction deformity, and that was not sufficient to interfere markedly with full function.

SUMMARY AND CONCLUSIONS

The need for careful collection and study of end results obtained with the various operative procedures designed for the restoration of function in ununited fractures of the femoral neck continues. As an aid in this study a well-defined set of criteria should be adopted to standardize the evaluation of end results by different authors.

At the Mayo Clinic the Brackett operation or the procedure as modified by Magnuson was used in seventy-one cases of nonunion after fracture of the femoral neck in the years 1920 to 1945 inclusive. Good results were obtained in 66.7 per cent of the sixty-three cases in which evaluation was possible.

Internal fixation by means of beef bone screws, or metallic nails or screws, was used in fifty-five of the seventy-one cases, and good results were obtained in thirty-five. In four of these fifty-five cases follow-up data were not adequate to allow evaluation.

Proper selection of cases, careful operative work, valgus position of the femoral head on the remodeled shaft, and adequate internal fixation are important in this operation.

REFERENCES

1. Leadbetter, G. W.: The Problem of the Fractured Hip, Nebraska M. J. **30**: 309-313, 1945.
2. Rowe, M. L., and Ghormley, R. K.: Brackett Operation for Ununited Fracture of the Neck of the Femur; a Report of Thirty-Four Cases, J. Bone & Joint Surg. **26**: 249-256, 1944.
3. Bickel, W. H., and Ghormley, R. K.: Brackett Operation for Ununited Fractures of the Neck of the Femur: Report of Two Cases, Proc. Staff Meet., Mayo Clin. **16**: 345-348, 1941.
4. Brackett, E. G., and New, May S.: Treatment of Old Ununited Fracture of the Neck of the Femur by Transplantation of the Head of the Femur to the Trochanter, Boston M. & S. J. **177**: 351-353, 1917.
5. Magnuson, P. B.: The Repair of Ununited Fracture of the Neck of the Femur, J. A. M. A. **98**: 1791-1794, 1932.
6. Colonna, P. C.: The Colonna Reconstruction Operation for Ununited Fractures of the Neck of the Femur; Analysis of Seventy Cases, J. Bone & Joint Surg. **21**: 701-714, 1939.
7. Henderson, M. S.: Ununited Fracture of the Neck of the Femur Treated by the Aid of the Bone Graft, J. Bone & Joint Surg. **22**: 97-106, 1940.
8. Gallie, W. E., and Lewis, F. I.: Ununited Fracture of the Neck of the Femur in the Aged, J. Bone & Joint Surg. **22**: 76-80, 1940.
9. Magnuson, P. B.: Report of Fifty-Nine Consecutive Cases of Ununited Fracture of the Neck of the Femur, SURGERY **7**: 763-772, 1940.
10. Reich, R. S.: Ununited Fracture of the Neck of the Femur Treated by High Oblique Osteotomy, J. Bone & Joint Surg. **23**: 141-158, 1941.
11. Campbell, W. C., and Smith, Hugh: Treatment of Ununited Fractures of the Neck of the Femur, Southwestern Med. **25**: 70-73, 1941.
12. Henderson, M. S.: Extra-articular Osteosynthesis; for Non-Union of Fracture of the Neck of the Femur, Arch. Surg. **42**: 557-565, 1941.
13. Hermann, O. J.: Ununited Hip Fractures, New England J. Med. 226: 601-605, 1942.
14. Speed, J. S., and McGehee, F. O.: Sub-trochanteric Osteotomy for Non-Union Fracture of Neck of Femur; Report of 52 Cases With End Results of 38, M. Rec. & Ann. **38**: 809-813, 1944.
15. Leadbetter, G. W.: Cervical-axial Osteotomy of the Femur; a Preliminary Report, J. Bone & Joint Surg. **26**: 713-720, 1944.
16. Stewart, J. D.: Subtrochanteric Osteotomy for Treatment of Nonunion of Hip Fractures, Northwest Med. **44**: 112-117, 1945.

PROLONGED SPINAL ANESTHESIA FOR OPERATIONS ON THE HIP AND LOWER EXTREMITY

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THE question of anesthesia for the elderly patient about to undergo reduction of a fractured hip or amputation of a gangrenous leg is always a difficult one. Problems in a large city hospital are the poor general condition of the patients and, in many cases, old age. In addition there are the complications of frequent fluoroscopic reduction with the automatic removal from consideration of all hydrocarbon agents that goes with this procedure and the indefinite duration of the operation itself. This depends on technical difficulties and cannot be forecast. For these reasons, we began in June, 1946, to use a concentrated solution of pontocaine-dextrose-ephedrine for unilateral spinal anesthesia in a search for a workable routine which would satisfy surgical requirements, remove the explosion hazard, and provide a reasonably safe anesthetic method. Our study covers all operations for fractured hip done between June 1 and November 30, 1946, and includes some other operations confined to one lower extremity done under this technique. There were sixty-seven cases studied during the six-month period.

The idea of using vasoconstricting drugs intrathecally is not new and was described in the early part of this century. In 1943 Romberger[1] mentioned mixing ephedrine with procaine; more recently Prickett, Gross, and Cullen[2] and Potter and Whitacre[3] have reviewed the literature and reported clinical studies in which vasopressor drugs were administered subdurally. These recent reports indicate that there is prolongation of anesthesia with equal or smaller doses of spinal anesthetic agents, and no increase in complications during or after anesthesia.

Unilateral spinal anesthesia is familiar to all who have seriously interested themselves in spinal anesthesia. Maxson[4] stated, "It is quite possible to secure anesthesia much more intense on one side than the other, and of longer duration, by keeping the patient motionless for several minutes. True unilateral anesthesia has not occurred in the writer's experience, but it could be produced if any advantage were to be gained thereby."

The purpose of this paper is to present a technique for selected unilateral cases in which it is felt that a definite advantage *is* gained by unilateral spinal anesthesia prolonged by the use of vasopressor drugs intrathecally.

TECHNIQUE

When premedication is indicated, morphine and scopolamine are administered hypodermically ninety minutes before operation in the proportion of 25 parts of morphine to 1 of scopolamine; or a rapidly acting barbiturate such

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as pentobarbital is given by mouth. Ten to twenty minutes before administration of the spinal anesthetic, 20 mg. of desoxyephedrine (Methedrine or "Drinalfa") are injected intramuscularly in most cases. This agent has been found to be more efficacious in preventing blood pressure fall than the usual 50 mg. of ephedrine.[5, 6]

The spinal anesthetic solution is made up by mixing dry tetracaine (pontocaine, niphanoid) in 10 per cent dextrose so that 1 c.c. of solution contains 10 mg. of pontocaine. The dose of pontocaine varies from 3 to 10 mg., so that 0.3 to 1.0 c.c. of the pontocaine in dextrose solution is taken up into a syringe. To this is added 1 c.c. of ephedrine sulfate containing 50 mg. of the salt. The total volume of the mixture will thus be between 1.3 and 2.0 c.c. No spinal fluid or other diluent is added, as a reasonably concentrated hyperbaric solution is desired.

The patient is then placed in the lateral position on the affected side. The spinal puncture is made as rapidly as possible, since lying on the affected side is painful, and the spinal anesthetic solution is injected very slowly over a period of two minutes by the clock. The operating table is level and is kept this way for at least ten minutes after completion of the injection. He may then be positioned for surgical convenience. An intravenous infusion of saline or glucose solution is usually started, to which blood or plasma may be connected for later use. Weighting the pontocaine with dextrose is necessary to make the anesthetic solution heavier than spinal fluid. Thus gravity carries more of it to the dependant half of the dural sac where it bathes the roots of the nerves supplying the affected leg. A small volume increases hyperbaricity and minimizes dispersion during injection. Slow injection also decreases dispersion. The ephedrine lengthens the time required for fixation of the spinal anesthetic solution so that a minimum of ten minutes is required, but this is more than compensated for by the increase in total duration which it provides.

This attempt to concentrate the solution around the nerve roots of the affected side makes a smaller dose produce more complete and longer lasting anesthesia. Since the leg, thigh, and buttock are innervated by the first lumbar to the second sacral spinal segments, an injection at the third or fourth lumbar interspace will reach all nerve roots concerned with a minimum of dispersion.

RESULTS

In all sixty-seven cases the anesthesia was satisfactory in speed of onset and in producing complete relaxation of the large muscles about the hip. The unaffected leg could be freely moved throughout the operation in most cases, although some paresthesia was usually present in it.

In Table I it is shown that in cases lasting less than 1½ hours, the duration was sufficient in all cases with or without ephedrine added to the anesthetic mixture. However, in cases lasting more than 1½ hours the prolongation achieved with ephedrine is evident. Table II shows the two cases out of thirty-four lasting more than ninety minutes in which ephedrine was used, where supplementary anesthesia was required, and the two cases out of eight

of similar duration where it was not used, which required a supplement. The longest case (Case 30) in the series was a hip osteotomy lasting three hours and thirty-five minutes under 10 mg. of pontocaine with 50 mg. of ephedrine in a muscular 36-year-old man. He required no supplement, and volunteered that the pain did not appear for two hours after operation was completed. He had completely unilateral anesthesia.

TABLE I. COMPARISON OF PONTOCAINE-DEXTROSE WITH AND WITHOUT 50 MG. EPHEDRINE SULFATE INTRATHECALLY

	SATISFACTORY	SUPPLEMENT	AVERAGE DURATION
With ephedrine			
Less than 90 minutes	18	0	70 minutes
More than 90 minutes	32	2	135 minutes
Without ephedrine			
Less than 90 minutes	7	0	67 minutes
More than 90 minutes	6	2	130 minutes

Sixteen of the procedures were closed reductions of hip fractures done under fluoroscopic guidance. The anesthesia was of such duration in these cases that not even the addition of morphine was necessary. The smallest doses of pontocaine were used in these patients.

There were no immediate or postoperative complications attributed to the anesthesia by surgeons or anesthesiologists. No postoperative atelectases occurred, which is especially notable since thirty-seven of the sixty-seven patients (55 per cent) were more than 70 years old. No cases of nerve root damage or irritation were encountered.

Altogether, fifty-two patients were given intrathecal ephedrine, and in fifteen it was omitted. Table III shows that there were nine deaths among the fifty-two patients who received ephedrine, and six deaths among the fifteen who did not.

Five of the fifteen deaths were due to pulmonary emboli. Two of these occurred within seven hours of operation, and it is presumable that phlebo-

TABLE II. CASES REQUIRING SUPPLEMENTARY ANESTHESIA

CASE	NAME	SEX	AGE	PROCEDURE	ANESTHETIC: PONTOCAINE (MG.)	ANESTHETIC: EPHEDRINE (MG.)	TOTAL TIME (IN MIN.)*	SUPPLEMENT: AGENT	SUPPLEMENT: TIME AFTER SPINAL (MIN.)	REMARKS
8	J. M.	M	35	Triple arthrodesis of ankle with tendon transplant	7.0	50	170	Nitrous-ether	100	Pain from tourniquet
19	S. F.	F	63	Open reduction of hip with nail and plate	5.0	50	150	Cyclopropane	70	
33	M. K.	F	25	Osteotomy of hip	15.0	0	165	Pentothal	90	
36	A. C.	F	63	Open reduction of hip with nail and plate	7.5	0	170	Cyclopropane	90	Psychotic, noisy

*Time from injection of spinal anesthetic solution until completion of operation including cast, if any.

TABLE III. - DEATHS WITHIN THIRTY DAYS OF OPERATION

CASE	NAME	SEX	AGE	PROCEDURE*	ANESTHETIC		DEATH		
					PONTOCAINE (MG.)	EPHEDRINE (MG.)	TIME†	CAUSE	TIME P.O.
1	E. S.	F	66	Osteotomy of hip	8	50	185	Congestive failure (P)	7 days
4	M. L.	F	77	Open reduction of hip	7	50	135	Multiple pulmonary emboli (P)	7 hr.
5	B. M.	F	78	Open reduction of hip	5	--	130	Bronchopneumonia, gangrenous cystitis (P)	10 days
6	A. A.	M	71	Open reduction of hip	5	50	145	Hemorrhage from gastric ulcer (P)	20 days
9	C. R.	F	92	Closed reduction of hip	5	25	75	Pulmonary embolus	15 days
15	S. R.	M	84	Closed reduction of hip	7	50	70	Pulmonary embolus (P)	10 days
34	M. F.	F	63	Closed reduction of hip	10	--	110	Bronchopneumonia	9 days
38	A. U.	M	85	Open reduction of hip	5	--	115	Bronchopneumonia, congestive failure (P)	18 days
39	F. J.	F	79	Closed reduction of hip	4	--	110	Bronchopneumonia (P)	21 days
40	A. B.	F	97	Closed reduction of hip	3	--	80	Bronchopneumonia	25 days
45	M. F.	F	80	Open reduction of hip	5	50	85	Pulmonary embolus (P)	4 hr.
47	T. B.	M	89	Open reduction of hip	5	50	160	Inanition and urinary complication	23 days
52	H. H.	M	83	Open reduction of hip	5	--	80	Pulmonary embolus (P)	4 days
56	B. B.	F	76	Mid-thigh amputation	3	50	30	Uremia, diabetes	8 days
67	A. K.	F	73	Open reduction of hip	10	50	135	Bronchopneumonia (P)	19 days

*All open reductions had Neufeld nail or Thornton plate with Smith-Petersen nail; all closed reductions had insertion of Smith-Petersen nail.

†Time in minutes from spinal injection to completion of operation. (P) Indicates findings confirmed at post-mortem examination.

thrombosis existed before operation was started. Neither had blood pressure drops of any consequence during operation. Of the other three such deaths only one (Case 9) had a marked fall in blood pressure during operation, and since she survived fifteen days, we do not feel the spinal anesthetic and its accompanying blood pressure fall were necessarily responsible for the embolus. In none of the cases in this series was prophylactic or therapeutic vein ligation performed. Bronchopneumonia was the primary cause or a complicating factor in six deaths. Only two other cases of bronchopneumonia occurred in the series. Seven of the eight cases of bronchopneumonia encountered occurred in patients over 70 years of age, and the eighth case was a man of 63 years. Only one patient complained of headache following spinal anesthesia, but the aged usually complain less.

In Table IV are given data on ten of the longer cases in the series, all of which survived. The anesthesia records of two of these patients are shown in Figs. 1 and 2. The level blood pressure and relatively stable pulse rate in Case 54 are illustrative. In Case 30 (Fig. 2) the pulse and blood pressure

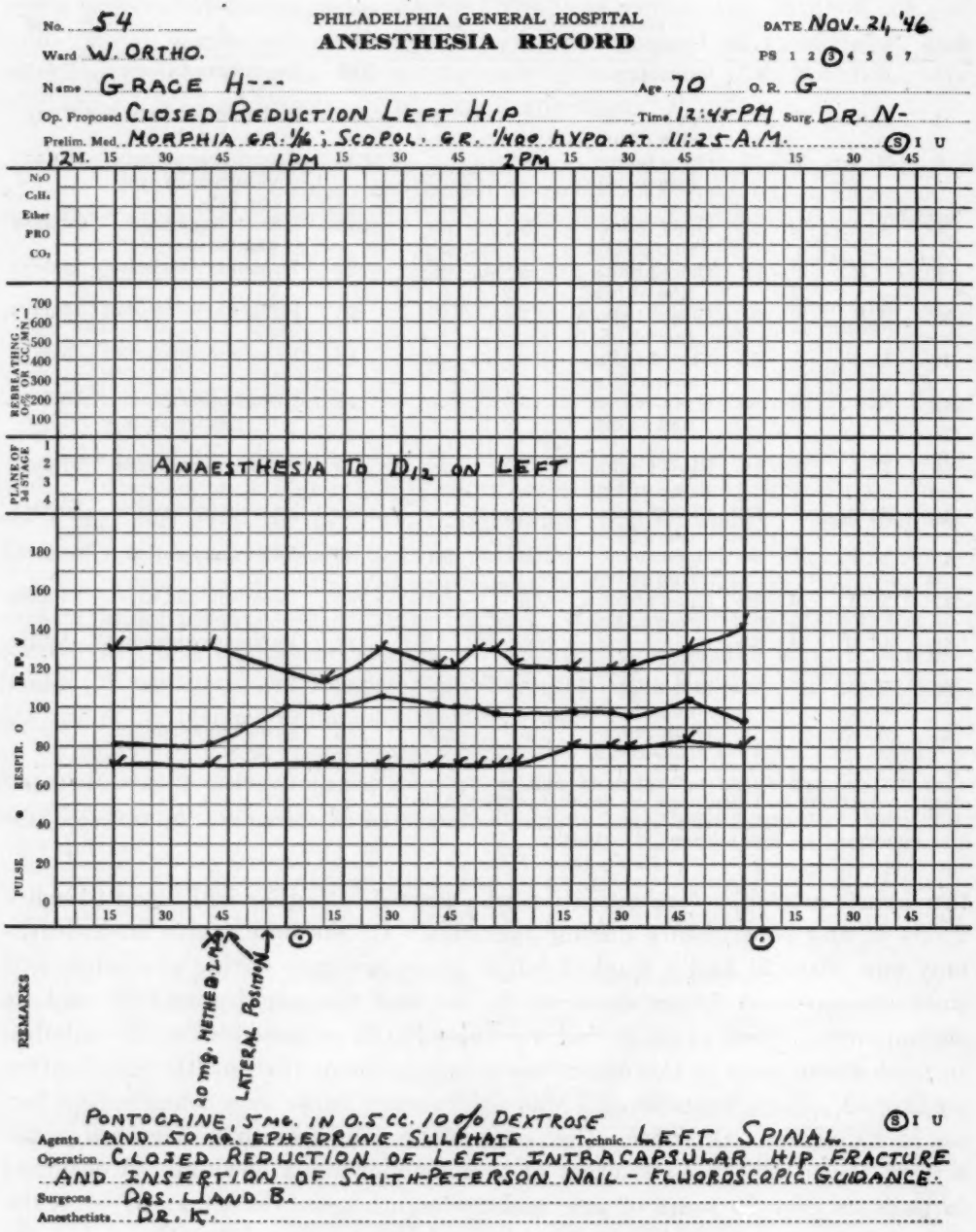
No. 54
PHILADELPHIA GENERAL HOSPITAL
ANESTHESIA RECORD
DATE Nov. 21, '46
Ward W. ORTHO.
PS 1 2 S 4 5 6 7
Name GRACE H---
Age 70 O. R. G
Op. Proposed CLOSED REDUCTION LEFT HIP
Time 12:45 PM Surg. DR. N-
Prelim. Med. MORPHIA GR. 1/6; SCOPOL. GR. 1/100 HYPO AT 11:25 A.M.
S I U
12M. 15 30 45 1PM 15 30 45 2PM 15 30 45 15 30 45
N2O
C2H4
Ether
PRO
CO2
REBREATHING O2% OR CC./MIN.
700 600 500 400 300 200 100
PLANE OF 3d STAGE
1 2 3 4
ANAESTHESIA TO D12 ON LEFT
B. P.
RESPIR.
PULSE
180 160 140 120 100 80 60 40 20 0
15 30 45 15 30 45 15 30 45 15 30 45
REMARKS
20 mg. METHEDRINE
LATERAL POSITION
PONTOCAINE, 5 MG. IN 0.5 CC. 10% DEXTROSE
S I U
Agents AND 50 MG. EPHEDRINE SULPHATE Technic LEFT SPINAL
Operation CLOSED REDUCTION OF LEFT INTRACAPSULAR HIP FRACTURE AND INSERTION OF SMITH-PETERSON NAIL - FLUOROSCOPIC GUIDANCE.
Surgeons DRS. L AND B.
Anesthetists DR. K.

Fig. 1.—Anesthesia record, Case 54.

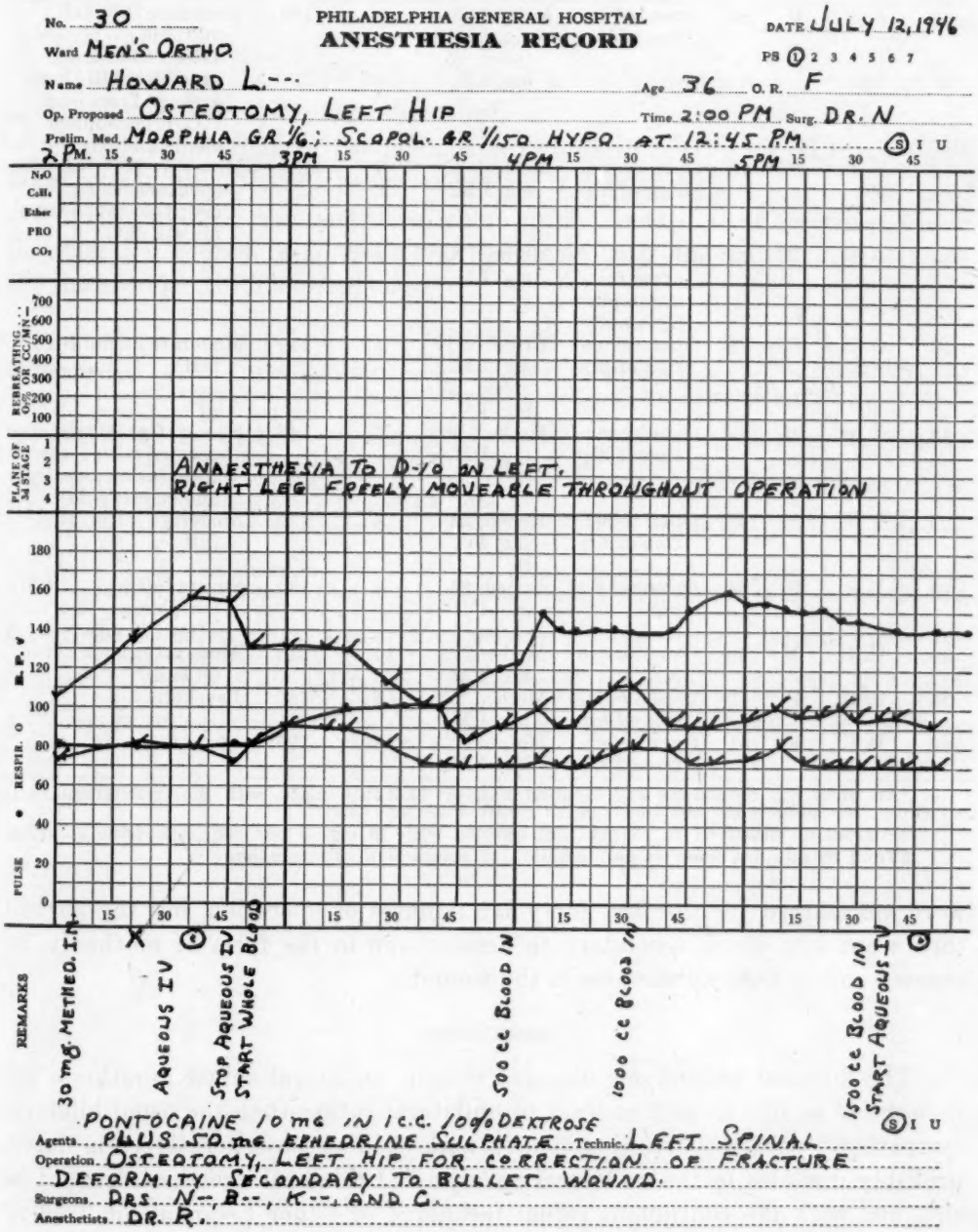
No. 30
PHILADELPHIA GENERAL HOSPITAL
ANESTHESIA RECORD
DATE JULY 12, 1946
Ward MEN'S ORTHO
PS 0 1 2 3 4 5 6 7
Name HOWARD L.---
Age 36 O. R. F
Op. Proposed OSTEOTOMY, LEFT HIP
Time 2:00 PM Surg. DR. N
Prelim. Med. MORPHIA GR 1/6; SCOPOL. GR 1/150 HYPO AT 12:45 PM
2PM 15 30 45 3PM 15 30 45 4PM 15 30 45 5PM 15 30 45
N2O
Cal.
Ether
PRO
CO2
REBREATHING O2% OR CC/MIN.
PLANE OF 3d STAGE
ANAESTHESIA TO D-10 IN LEFT.
RIGHT LEG FREELY MOVEABLE THROUGHOUT OPERATION
B. P.
RESPIR.
PULSE
REMARKS
30 mg. METHED. I.M.
AQUEOUS IV
STOP AQUEOUS IV START WHOLE BLOOD
500 cc BLOOD IN
1000 cc BLOOD IN
1500 cc BLOOD IN START AQUEOUS IV
PONTOCAINE 10 mg IN 1 c.c. 10% DEXTROSE
PLUS 50 mg EPHEDRINE SULPHATE
Agents
Technic LEFT SPINAL
Operation OSTEOTOMY, LEFT HIP FOR CORRECTION OF FRACTURE DEFORMITY SECONDARY TO BULLET WOUND.
Surgeons DRS. N--, B--, K--, AND C.
Anesthetists DR. R.

Fig. 2.—Anesthesia record, Case 30.

TABLE IV. PERTINENT DATA ON TEN ILLUSTRATIVE CASES, WITH NO DEATHS

CASE	NAME	SEX	AGE	PROCEDURE*	PRESSOR DRUG	PONTOCAINE (MG.) †	TIME‡	REMARKS INCLUDING OPERATIVE AND P.O. COMPLICATIONS
3	J. S.	F	80	Open reduction of hip	Methed. 20 mg. I.M., ephed. 25 mg. I.V.	5	165	Moderate B.P. fall, morphia gr. 1/12 I.V. after 140 min. followed by chill; hemorrhage from wound P.O. bronchopneumonia 2nd day
7	E. F.	F	70	Open reduction of hip	Methed. 20 mg. I.M.	5	120	Moderate B.P. fall with spontaneous recovery; bronchopneumonia 4th day
14	G. W.	M	78	Hip spica after failure to place S.-P. nail	Methed. 20 mg. I.M.	7	155	
17	G. O.	F	75	Open reduction of hip	Drinalfa 10 mg. I.M., ephed. 25 mg. I.V.	7	150	Moderate initial B.P. fall
18	G. F.	M	68	Open reduction of hip	Methed. 20 mg. I.M.	7	145	Shock after 70 min., recovered with forced transfusion; nausea and emesis 1 day P.O.
23	F. V.	M	58	Open reduction of hip	Ephed. 25 mg. IV. 2x	8	170	Moderate initial B.P. fall
29	E. S.	F	66	Osteotomy of hip	Ephed. 25 mg. IV.	8	180	Severe initial B.P. fall; morphia gr. 1/8 I.V. after 170 min.
30	H. L.	M	36	Osteotomy of hip	Methed. 30 mg. I.M.	10	215	Moderate shock after 90 min.
54	G. H.	F	70	Closed reduction of hip	Methed. 20 mg. I.M.	5	160	Psychotic
66	B. K.	F	51	Open reduction of hip	Methed. 20 mg. I.M.	6	125	

*All open hip reductions had Neufeld nail or Thornton plate with Smith-Petersen nail; all closed hip reductions had insertion of Smith-Petersen nail.

†Pontocaine dissolved in 10 per cent glocose with 50 mg. 5 per cent ephedrine solution.

‡Time in minutes from spinal injection to completion of operation.

were maintained for the first forty-five minutes of operation, but the patient then went into shock secondary to hemorrhage in the form of markedly increased oozing from all surfaces in the wound.

DISCUSSION

The minimal physiologic changes seen in unilateral spinal anesthesia are thought to be due in part at least to unilateral rather than the usual bilateral sympathetic paralysis. Less difficulty with voiding postoperatively is noted, probably due also to the unilateral paralysis. Unilateral anesthesia cannot be obtained with the continuous spinal technique of either Lemmon[7] or Touhy.[8] The single dose method is simpler to induce and obviates the difficulties of maintaining needle or catheter position during operation.

It is not felt that this spinal method is superior to good inhalation anesthesia for operations done in the light. But it is felt that for those cases done under fluoroscopic guidance where explosive agents cannot be used, and where

prolonged periods of darkness make adjustments of gaseous anesthetic mixtures difficult, that this method of spinal anesthesia is a positive, relatively simple technique with a wide margin of safety.

SUMMARY

1. A method for prolonged unilateral spinal anesthesia with pontocaine-dextrose-ephedrine mixture is described.

2. The application of the method in prolonged operations on the hip and lower extremity in the old, poor-risk patient is discussed.

3. The method has particular value in manipulations of fractures where the duration cannot be forecast and the majority of the operation is done in the dark under the fluoroscope.

REFERENCES

1. Romberger, F. T.: Spinal Anaesthesia—Practical Facts and Common Fallacies—Clinical Research on Prolonged Spinal Anaesthesia Using Vasoconstrictor Drugs, Anesth. & Analg. **22**: 352-363, 1943.
2. Prickett, M. D., Gross, E. G., and Cullen, S. C.: Spinal Analgesia With Solutions of Procaine and Epinephrine, Anesthesiology **6**: 469-475, 1945.
3. Potter, J. K., and Whitacre, R. J.: Pontocaine-Dextrose-Ephedrine for Spinal Anaesthesia, Anesthesiology **7**: 499-504, 1946.
4. Maxson, L. H.: Spinal Anaesthesia, Philadelphia, 1938, J. B. Lippincott Company, p. 132.
5. Dripps, R. D., and Demming, M. V. N.: An Evaluation of Certain Drugs Used to Maintain Blood Pressure During Spinal Anaesthesia, Surg., Gynec. & Obst. **83**: 312-322, 1946.
6. Anderson, Bruce M.: The Use of Methedrine as a Vasoconstrictor With Spinal Anaesthesia, Anesthesiology **7**: 1-9, 1946.
7. Lemmon, W. T.: A Method for Continuous Spinal Anaesthesia, Ann. Surg. **3**: 141-145, 1940.
8. Touhy, E. B.: Use of Continuous Spinal Anaesthesia Utilizing Ureteral Catheter Technique, J. A. M. A. **128**: 262-263, 1945.

LYMPH LEAKAGE (LYMPHORRHEA)*

A Complication of Saphenous Vein Ligation, With Suggestions for Treatment

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IT IS amazing that lymph leakage should be so unusual a complication in view of the frequency of saphenous vein ligations, the propinquity of the subinguinal lymphatics and nodes to the saphenofemoral junction, and the slow clotting of peripheral lymph. The treatment of varicose veins by high saphenous vein ligation, with or without retrograde injections, has become one of the commonest of all surgical procedures. Perilymphangitis may be present, and the lymphatics swollen and engorged with lymph. In these circumstances, a tear in the wall of a lymphatic would produce an unrecognized lymph leak which might persist.

Harkins and Schug[1] have described a single instance of lymph leakage after saphenous vein ligation. At operation, they noted "a large adherent overlying lymph gland"; a lymph leak appeared a few days later and persisted for three months. The disaster, following injury to the thoracic duct frequently referred to in surgical texts is due chiefly to the lack of clotting qualities in the chyle. Reference to lymph leakage after femoral vein ligation is rare[2] even though the operation involves deeper dissection and wider retraction than the much more common procedure of saphenous vein ligation.

The lymphatics of the leg consist of two sets, superficial and deep, each following the veins closely in distribution. The superficial lymphatics lie subcutaneously in the superficial fascia, running in three trunks, one following the course of the long saphenous vein, another along the short sapheonus vein, and a third arising in the gluteal region. The internal lymphatic trunks, which follow the long saphenous vein, are three or four in number and arise from a plexus on the dorsum of the foot and drain the toes, sole, and both borders of the foot. The external trunks, which parallel the short saphenous vein, are two or three in number, arising in the region of the heel and posterior half of the outer edge of the foot, and enter the internal trunks, which terminate in the superficial lymph nodes. This group of nodes lies beneath the superficial fascia in Scarpa's triangle. These nodes are large, vary in number from ten to twenty, and may be divided arbitrarily into a superior and inferior group by a horizontal line through the saphenous opening. The inferior group of subinguinal lymph nodes is placed on either side of the upper end of the long saphenous vein and drains the efferent lymphatics from the lower leg, as well as those from the genitals, perineum and buttocks.

It is these subinguinal nodes and the superficial lymphatics coursing along the saphenous vein which are most likely to be torn in the dissections of the saphenofemoral junction. These lymphatics are small, friable, and lack the protective coloring of veins. Vigorous displacement of an overriding lymph node by a retractor might easily rupture one of these small lymph vessels. A

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*Neither "lymph leakage" nor "lymphorrhea" are mentioned in the Quarterly Cumulative Index Medicus.

bold incision, deepened abruptly without first elevating the skin margins, could easily sever one of these lymphatics. The excision of an overlying lymph node, which obstructed the field of operation, could tear some of these tiny channels even with careful dissection and without recognition of the injury at the time. Dennis[3] is to be credited with the observation, made during a high femoral ligation, of "a small spurting vessel. It spurted a colorless clear liquid, not blood, and it was ligated."

Lymph clots more slowly than blood and is lower in protein content.[4-7] In proportion to its protein content, lymph contains less of the coagulation factors than blood plasma. The protein content of the peripheral lymph from a dog's leg is only one-fourth of the normal serum protein, 1.66 to 6.59 per cent.[6] It should not be unfair to assume that fibrinogen is materially and possibly proportionately reduced, although there are no available quantitative values for peripheral lymph fibrinogen. The viscosity of lymph is less than that of blood serum and varies directly with its protein content.

Howell[7] has shown that delayed clotting is due to lack of thromboplastic material. In the blood, this substance is contributed chiefly by the platelets and to a minor degree by the leucocytes. In lymph, platelets are lacking, and the white cells are poor sources of thromboplastin. Howell also stated that lymph contained a relative excess of antithrombin. The delay in the clotting of lymph may be due to lower viscosity, lower protein content, lower fibrinogen content, lack of thromboplastin, excess of antithrombin, or more likely a combination of these factors.[5, 6]

I have encountered three instances of lymph leakage after saphenous vein ligation. The first occurred in one of my own patients, a middle-aged Negro, with varicosities and recurring ulceration confined to one leg, which had begun many years before as a phlebitis, complicating typhoid fever. Four days after ligation a swelling appeared beneath the incision, which when opened poured out an estimated 300 c.c. of clear lymphlike fluid. The leak persisted for three weeks, finally subsiding after repeated packing and tight bandaging, while the patient was ambulatory. At operation, three adherent lymph nodes overlying the saphenous bulb were retracted too vigorously.

A second case came to my attention, occurring in a middle-aged white woman, whose varicose veins were the site of an acute phlebitis. The left saphenous vein was ligated without retrograde injection, and five days later a painful swelling appeared beneath the operative scar, which, when incised drained lymph (clear serum). This leak lasted for two months, with intermittent drainage of lymph, described in the record as clear and of a serous nature, and finally the recurrent swelling was explored, revealing a thin-walled cyst filled with two ounces of clear opalescent fluid. The cyst wall was curetted and the wound packed wide open with gauze: The wound drained lymph for almost one month and then healed. This case also illustrates the greatly augmented lymph flow associated with phlebitis.

A third instance occurred in a white man, one week after saphenous vein ligation and retrograde injection with sodium morrhuate. A swelling at the site of operation was then incised with the escape of 75 c.c. of clear lymphlike fluid. The fluctuant tumor recurred after repeated drainages over a period

of nine months, at which time the wound was explored and a sac containing the same lymphlike fluid was excised. Recurring swelling and lymph leakage persisted another five months at which time the original incision was laid wide open and packed and bandaged tightly with subsequent healing. This is the only case in which a retrograde injection was done.*

There are several effective means of treatment. Obviously injury to the thin-walled lymphatics would not occur if they carried a colored fluid to facilitate their identity. The application of an elastic pressure bandage from the foot to above the incision, with elevation of the leg, will invariably stop the leak within a short time due to forcible collapse of the lymphatics and resultant slowing of the lymph flow to a rate at which clotting can occur. If the wound is laid open or if it disrupts from distention with lymph, firm packing of the wound beneath an elastic bandage will plug the leak and hasten clotting. The local application or injection of any thromboplastic material such as Thrombin Topical† should cause clotting by affording a surplus of thromboplastin in the subcutaneous tissues about the leak. Such an injection is not without danger.

Lymph will continue to leak from a torn lymphatic because it is too low in all the factors of coagulation to make a substantial clot. Drinker[5] has suggested not only that the lymphatic fibrinogen is low, but also that the fibrinogen in the subcutaneous tissues about the leak may fail to participate in the clotting process unless there is an excess of thromboplastic material present to bring about a coagulum of better quality. What he terms a rather crude though effective method of accomplishing this consists of crushing the subcutaneous tissues with the jaws of a hemostat in the region of the leak, thereby releasing excess tissue juice or extract which is high in thromboplastic material in the immediate vicinity of the fistula. Such a procedure would be attended by some danger of infection unless careful asepsis were observed.

These therapeutic suggestions are offered because of the possibility of this exceedingly annoying complication of the everyday procedure of saphenous vein ligation. That this complication has been barely mentioned before can be attributed either to its rarity, or, more likely, to its being regarded as of minor importance. No matter how trivial, anything that can be so annoying both to patient and doctor deserves both recognition and prompt relief.

REFERENCES

1. Harkins, H. N., and Schug, R.: The Surgical Managament of Varicose Veins; Importance of Individualization in the Choice of Procedure, SURGERY 11: 402-421, 1942.
2. Allen, A. W., Linton, R. R., and Donaldson, G. A.: Venous Thrombosis and Pulmonary Embolism, J. A. M. A. 128: 397-403, 1945.
3. Dennis, Clarence: Disaster Following Femoral Vein Ligation for Thrombophlebitis; Relief by Fasciotomy; Clinical Case of Renal Impairment Following Crush Injury, SURGERY 17: 264-269, 1945.
4. Drinker, Cecil K., and Field, Madeline: Lymph, Lymphatics and Tissue Fluid, Baltimore, 1933, Williams & Wilkins.
5. Drinker, Cecil K.: Personal Communication.
6. Drinker, Cecil K., and Yoffey, J. M.: Lymph, Lymphatics and Lymph Tissue, Cambridge, 1941, Harvard University Press.
7. Howell, W. H.: Coagulation of Lymph, Am. J. Physiol. 35: 483-491, 1914.

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†Manufactured by Parke, Davis & Company, Detroit, Mich.

Case Reports

MAXILLARY TUMOR OF RETINAL ANLAGE

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HEREIN is reported a benign neoplasm removed from the maxilla of a 6-month-old infant and composed of tissue elements of the retina. This is believed to be the first such growth ever recorded.

REPORT OF CASE

A 6-month-old white female child was admitted to the University of Oklahoma Hospitals, Oklahoma City, March 1, 1946, with a firm mass protruding from the hard palate. The mother, 23 years old, stated that the patient was her second child, born after an uneventful pregnancy, at term, with no complications of labor or of delivery. At birth the child weighed 8 pounds and presented no abnormalities. Development was unimpaired and she was apparently perfectly well until December, 1945. At this time, when about 4 months old, she fell and struck the upper lip, over which a blue streak appeared. The next day the area became swollen to such an extent that the physician incised the lip from the inside of the mouth. Bright red unclotted blood was obtained. This reduced the size of the lip temporarily.

On admission to the hospital the child was well developed, well proportioned, well nourished, and in apparent good health. The upper lip was blue and somewhat swollen and distorted. A nontender, firm mass, about 5 cm. in diameter, protruded into the mouth over the anterior portion of the right maxilla distorting the right side of the upper lip. The mass appeared to be attached to the bone. The overlying mucosa of the palate and gums was intact. Other physical findings and examination of the blood and urinalysis were essentially negative. Roentgenographic examination of the face disclosed a soft tissue tumor in the right anterior maxillary region with displacement of the teeth (Fig. 1). The heart was of usual size, shape, and position. The lung fields were clear.

On March 8, 1946, under endotracheal ether anesthesia, the right external carotid artery was ligated. An elliptical incision was then made through the mucous membrane of the mouth and periosteum, directly over the mass. The soft tissues with the periosteum were elevated. The alveolar process was divided medially and laterally to the tumor, after which the tumor shelled out without difficulty. The bleeding areas in the bone were controlled with bone wax, the roof of the mouth was reconstructed, and the space packed with sulfanilamide ointment gauze, the end of which was brought out through the medial end of the incision just behind the lip. Ophthalmoscopic examination, March 14, 1946, disclosed no visual disturbances and no changes in the eye grounds. The patient made an uneventful recovery and, with the wound completely healed, she was discharged from the hospital on March 27, 1946. When seen again on Nov. 14, 1946, she was in good health, growing, and gaining weight normally. There was no recurrence of the growth. The two sides of the maxilla were symmetrical with practically no deformity of the mouth and face (Figs. 2 and 3).

The specimen consisted of a globular, somewhat lobulated firm mass, 5 by 3 by 3 cm., weighing 25 Gm. Part of the surface, 4 by 3 cm., was covered by a smooth membrane; the remainder appeared raw. There were four teeth: two incisors, one canine, and one premolar.

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Fig. 1.

Fig. 2.

Fig. 3.

Fig. 1.—Soft tissue tumor in the right anterior maxillary region with displacement of the teeth.

Figs. 2 and 3.—Eight months after removal of the growth, there was no recurrence. The two sides of the maxilla are symmetrical and there is practically no deformity of the mouth and face.

The cut surfaces were smooth and slate black, streaked with gray-white (Fig. 4). The mass was bordered partly by a delicate bony plate, 0.1 to 0.3 cm. thick, and partly by a connective tissue capsule 0.2 cm. thick.

Microscopic preparations, stained with hematoxylin and eosin, and representing many parts of the specimen, disclosed various sized spaces lined with cuboidal cells. These contained brown or dark brown granules frequently obscuring the nucleus. In occasional lumina there were coarse infoldings resembling the ciliary processes of the eye (Fig. 5). In intimate contact with the lumina and also elsewhere there were sheets and nests of deeply stained round or oval nuclei with practically no cytoplasm and some fibrils (Fig. 6). All these cells were within a delicate fibrillar ground substance containing round or elongated vesicular nuclei with

Fig. 4.—The specimen removed is a globular mass, apparently encapsulated, weighing 25 Gm. The cut surfaces are smooth and slate black, streaked with gray-white.

hardly discernible cytoplasm fading into the fibrils. The fibrils in the stroma in places were wavy and delicate, such as are usually seen within nerves or in the perineurium. Elsewhere there were collagenous bundles. In a preparation including the smooth surface, there was a broad layer of stratified squamous epithelium with broad spinous and keratinized layers. The line between the squamous epithelium and the subjacent connective tissue was perfectly straight. In the deeper layers there were strands of epithelium composed of two rows of cell nuclei. Further inward there was a row of columnar cells in palisade arrangement, then cells with stellate processes in a light fibrillar ground substance. There were also occasional islands of osseous tissue. This zone merged with the connective tissue stroma of the spaces lined with cuboidal cells.

COMMENT

The spaces lined by cuboidal cells containing brown granules with their patterns of infoldings mimicked the ciliary processes of the eye. The sheets of almost naked cell nuclei resembled the nuclear layers of the retina or the cells seen in neuroblastomas. These microscopic appearances left no doubt that the principal component of the neoplasm was derived from cells of retinal

Fig. 5.

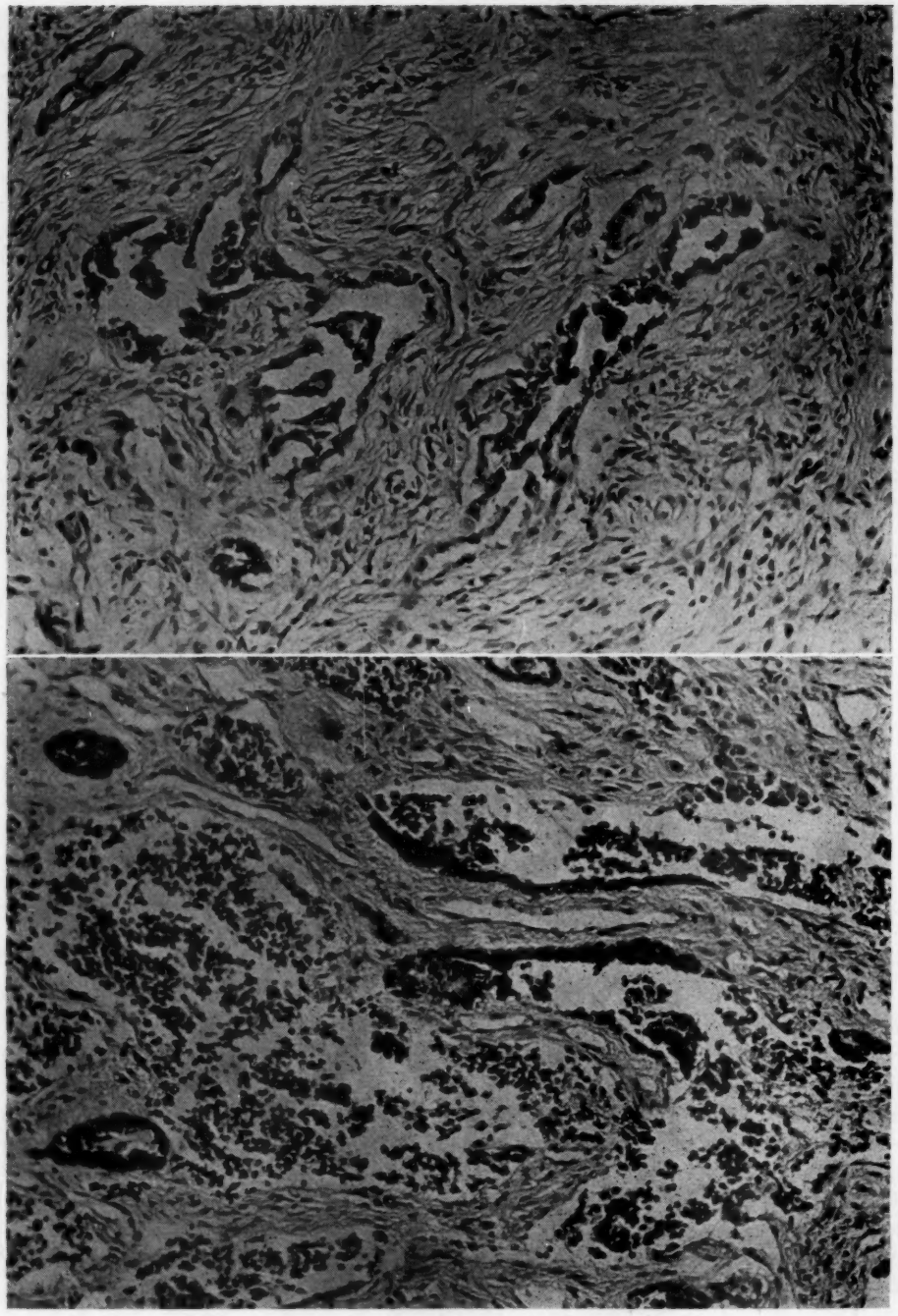

Fig. 6.

Fig. 5.—Various sized spaces lined with cuboidal cells, containing brown or dark brown granules, are seen frequently obscuring the nucleus. In occasional lumina there are coarse infoldings resembling the ciliary processes of the eye. (×125.)

Fig. 6.—In intimate contact with the lumina, lined by cuboidal cells, and elsewhere, there are sheets and nests of deeply stained round or oval nuclei with practically no cytoplasm and some fibrils. (×125.)

anlage. The benign character of the neoplasm was obvious since the tissue elements were in orderly relation to one another and no obvious activity of multiplication of the cells was seen. Furthermore, the tumor was well encapsulated and did not invade adjacent structures. The size of the neoplasm, however, suggested that it had a growth potentiality similar to that of the individual. Had it not been removed, the neoplasm probably would have enlarged progressively with the growth of the child.

SUMMARY

The clinical history is presented of a 6-month-old white girl who had a tumor removed from the maxilla. The neoplasm composed of tissue elements of the retina is believed to be the first tumor of retinal anlage ever recorded.

PERFORATION OF THE AORTA BY ACID GASTRIC CONTENTS AT SITE OF GASTROESOPHAGOSTOMY

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PERFORATION of the thoracic aorta is not common, but does occur from time to time, as reports in the medical literature indicate. In general when perforation takes place, it is caused by foreign bodies such as fish bones or pins in the esophagus, bullet wounds, or neoplastic invasion of the aortic wall from an esophogeal cancer. Isolated instances of perforations of the thoracic aorta by penetrating peptic ulcers of the esophagus have been reported by Christopherson,[1] Eversmann,[2] and Flower.[3] Dash[4] described a case of fatal hemorrhage from perforation of the abdominal aorta by a chronic ulcer of the third portion of the duodenum. Because of its unique nature the following case seems worthy of reporting.

A 59-year-old farmer entered Albany Hospital in September, 1945, with one year's history of indigestion, anorexia, epigastric pain, thirty pounds' weight loss, and no response to an ulcer regime. A gastrointestinal series was reported in part as follows: "As liquid barium passes down the esophagus, its progress is temporarily arrested at the cardiac end of the stomach by cardiospasm. There are no visible ulcerations or new growths." He was discharged on Sept. 30, 1945, to be followed by a gastroenterologist.

The symptoms steadily increased in severity and in addition he had frequent bouts of nausea and vomiting immediately after eating or drinking. He was readmitted on April 25, 1946, at which time roentgenographic studies of the gastrointestinal tract revealed a filling defect in the cardiac end of the stomach, toward the lesser curvature, consistent with a gastric neoplasm. The tumor also involved the distal portion of the esophagus.

On May 9, a large, ulcerated, granular mass 4 by 2.5 by 1.5 cm. was excised by a transthoracic approach and a gastroesophagostomy was performed. This mass was in the lesser curvature of the gastric fundus and extended into the submucosa of the distal esophagus. The spleen and tail of the pancreas were also resected. The specimen was reported pathologically as an infiltrating adenocarcinoma, grade II, of the cardiac portion of the stomach invading the submucosa and muscularis of the adjacent esophagus. The upper end of the esophagus was free of tumor. The spleen and pancreas were negative.

On May 14, a massive left-sided pleural effusion was found. May 16, he became markedly distended and the abdominal incision broke down. It was resutured with stainless steel on May 18. Thoracentesis fluid on May 23 contained milk curds and suggested a leak in the anastomosis with drainage of gastric contents into the left pleural cavity. Thoracotomy was done on May 24 and again gastric contents were identified in the pleural exudate. On May 29, jejunostomy was done to relieve abdominal distention and to facilitate feeding. Profuse drainage of thick brown fluid with a pH of 4 persisted from the left pleural cavity and the blood chlorides dropped from 450 to 370 mg. per cent. There was a leucocytosis of over 20,000 white blood cells per cubic millimeter. Despite supportive therapy he grew steadily weaker and on June 18 he suffered a sudden profuse hemorrhage from the mouth and died three hours later.

The pertinent findings at autopsy were limited to the operative site and the surrounding organs. The esophagus, stomach, and small intestine were filled with bright red clotted blood. At the site of the gastroesophagostomy in the left pleural cavity, a circular gaping defect 2.5 cm. in diameter was noted. The edges of this defect were firmly attached to the anterior wall of the thoracic aorta by inflammatory tissue through which ran a fistulous tract that extended to the aortic wall and actually penetrated its entire thickness. This tract was lined

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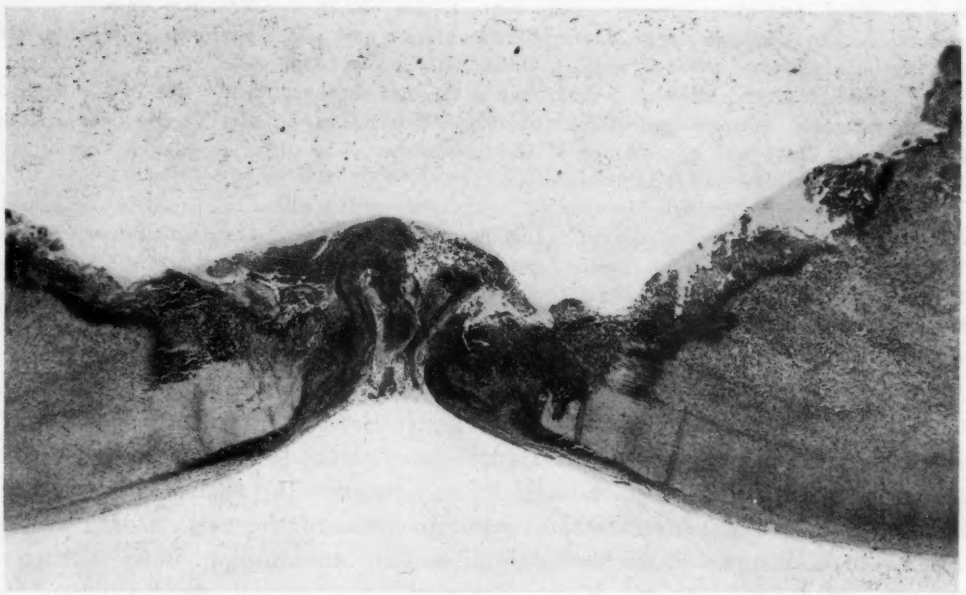

Fig. 1.—The perforation of the thoracic aorta is lined by granulation tissue and acute inflammatory exudate. The intima is seen at the bottom of the section and is acutely inflamed at the edge of the perforation.

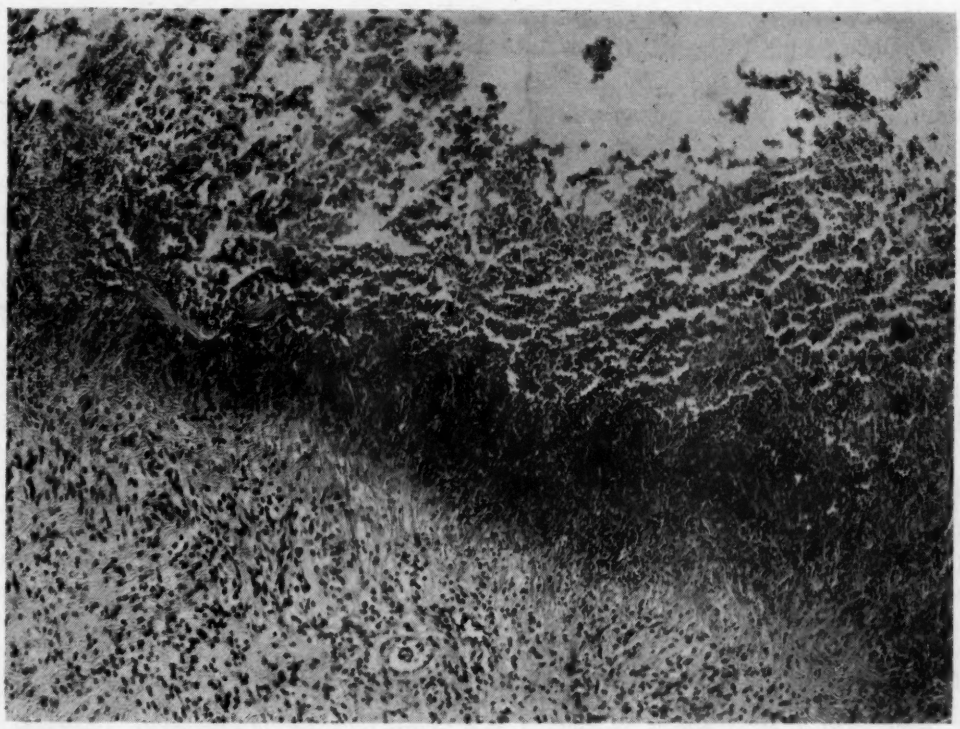

Fig. 2.—Section from the adventitial inflammatory mass at the junction of granulation tissue (below) and acute inflammatory exudate (above) demonstrates the coagulative necrosis commonly seen in peptic ulcers.

by hemorrhagic and blood covered inflammatory tissue. When the aorta was opened, a small perforation 3 by 1 mm. in size was found in its anterior wall. This perforation communicates with the fistulous tract through which a probe could easily be passed.

Microscipic examination of sections taken through the anastomotic site in the stomach showed extensive necrosis and chronic active inflammation on the gastric side of the anastomosis. There was no evidence of residual tumor. The distal esophagus showed only limited chronic submucosal inflammation.

A section taken through the fistulous tract at the point where it opened into the aorta showed complete destruction of the entire thickness of the aorta wall over a small area (Fig. 1). The tract itself was lined by focally hemorrhagic and acutely inflamed granulation tissue. At the junction between granulation tissue and acute inflammatory exudate, a peculiar zone of coagulative necrosis, similar to that found on the base of a typical chronic peptic ulcer, was present (Fig. 2).

COMMENT

This case is noteworthy because it illustrates what appears to have been a digestive, necrotizing effect of acid gastric juice on the tissues of the aortic wall. Apparently the irritating juice made its way through the periaortic soft tissues finally to erode and penetrate the entire thickness of the aorta with resulting massive hemorrhage. Particularly significant, in our opinion, is the nature of the necrosis and the inflammatory reaction, for the edges of the fistulous tract leading to the aortic wall bear a striking similarity to the base of a typical peptic ulcer. There may be seen the superficial inflammatory exudate, the underlying necrotic granulation tissue, and beneath that viable and inflamed granulation tissue.

There seems to be little doubt that the aortic perforation in this instance was caused by leakage of acid gastric contents from the operative defect. No residual neoplastic tissue was found in either the stomach or esophagus and there was no evidence of new growth in or near the aorta.

Since the thoracic aorta is in such close proximity to the esophagus and appears to be susceptible to the destructive effects of the gastric juices, one might well raise the question as to the possible danger of gastroesophagostomy if postoperative leakage occurs. If it can be performed, esophago-jejunostomy, where the presence of gastric juices can be eliminated, might be preferable. The absence of gastric juices might well diminish the eroding, penetrating necrotizing effect of any secretions which leaked through a defect at the site of anastomosis. It is not possible for us to say with certainty that the elimination of gastric secretions would prevent such a penetrating lesion as that found in this patent. It would seem to be a reasonable deduction, however, because the nature of the necrosis and the character of the lesion suggest that the acid digestive juices played a definite role in bringing about the extensive tissue damage that resulted ultimately in erosion through the aortic wall with final fatal massive hemorrhage.

REFERENCES

1. Christopherson, J. B.: A Simple Ulcer of the Esophagus Perforating the Descending Portion of the Aortic Arch and Causing Fatal Hematemesis, Lancet 1: 369, 1917.
2. Eversmann, J. H. L., quoted by Tileston, W.: Peptic Ulcer of the Esophagus, Am. J. M. Sc. 132: 240, 1906.
3. Flower, W. H.: Case of Perforating Ulcer of Esophagus Which Caused Death by Penetrating the Aorta, London Lancet 2: 158, 1853.
4. Dash, P. M.: Perforation of Duodenal Ulcer Into Aorta, Brit. M. J. 1: 570, 1940.

SURGICAL MANAGEMENT OF ILEAL ATRESIA IN THE NEWBORN INFANT

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ATRESIA of the terminal portion of the ileum is an exceedingly rare but frequently fatal congenital anomaly.[1, 2] Early diagnosis and prompt surgical relief of intestinal obstruction are immediately life-saving. In the usual case, however, it is necessary to exteriorize the proximal loop of distended and edematous ileum (Table I). Such an end-ileostomy usually enforces intolerable dehydration upon the newborn infant. The succus entericus may be lost directly through the ileostomy, or intestinal obstruction may recur in consequence of constrictive edema of the exteriorized loop of ileum. Thus, early re-establishment of intestinal continuity is an obvious desideratum in treatment. With presently available chemotherapeutic agents, the risk of peritonitis is no longer a contraindication to early anastomosis. The only limiting factors are the physical integrity of the bowel to be sutured and hydration of the infant. In the case to be reported, secondary side-to-side anastomosis was performed on the fourth postoperative day shortly after the first spontaneous discharge of ileal contents.

REPORT OF CASE

A full-term white male infant, weighing 6 pounds, 3 ounces, was delivered normally on March 27, 1946. Shortly after the child was taken to the nursery, abdominal distention was noted. A tap water enema resulted in expulsion of white, firm, inspissated mucus. No meconium was obtained. The child had refused to nurse and was listless. At the age of thirty hours, the baby vomited and distention was increasing.

Examination of the abdomen revealed pronounced distention with tympany. Abdominal auscultation disclosed hyperactive peristalsis. No masses were palpated. The rectum was empty except for white viscid mucus. Faber's test of the rectal mucus did not reveal any cornified epithelial cells, hair, or bile. Roentgenograms showed dilated loops of small bowel with fluid levels in the upper portion of the abdomen. No gas was visualized in the lower part of the abdomen or in the colon. Surgical consultation forty-eight hours after birth resulted in the clinical diagnosis of mechanical obstruction of the terminal ileum, and operative intervention was advised.

The infant was prepared for operation by the administration of an infusion of a modified Hartman's formula and whole blood transfusions. Vitamin K was also given.

On March 29, 1946, under drop ether anesthesia, a paramedian, para-umbilical incision was made on the right side and the rectus muscle was retracted laterally. When the peritoneal cavity was opened, the small bowel was found to be dilated and edematous. This was packed away with a warm laparotomy square and the cecum located. The cecum and terminal ileum were collapsed. About 20 cm. from the ileocecal junction, there was a point of volvulus with a vascular omental band between the ileum and umbilicus. This band was freed, the

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vessels ligated, and the volvulus reduced. A point of complete atresia was found at one extremity of the volvulus. The bowel of the volvulus was dark, bluish-red in color, and not viable. The patient was in only fair condition at this point. Administration of the anesthetic was discontinued, operative manipulation was stopped, and oxygen was given. The point of atresia and volvulus, which measured approximately 45 cm. in length (Fig. 1), was resected and a double-barreled ileostomy was created. The child was then returned to the ward.

The patient's postoperative course was carefully followed by the pediatric and surgical staffs. Transfusions of whole blood were given liberally. A modified Hartman's electrolyte solution containing cevitamic acid was given intravenously in dosage according to body weight. Vitamin K was injected intravenously. The dosage of penicillin was 30,000 units every three hours. The patient was carefully observed for return of peristalsis and for the beginning of ileostomy drainage. In the late afternoon of the third postoperative day the first ileostomy movement occurred. On the morning of the fourth postoperative day, the ileostomy drainage was profuse. It had been planned to anastomose the bowel at this time and before the loss of succus entericus had created a problem of chemical imbalance. Consequently, the patient was returned to the operating room.

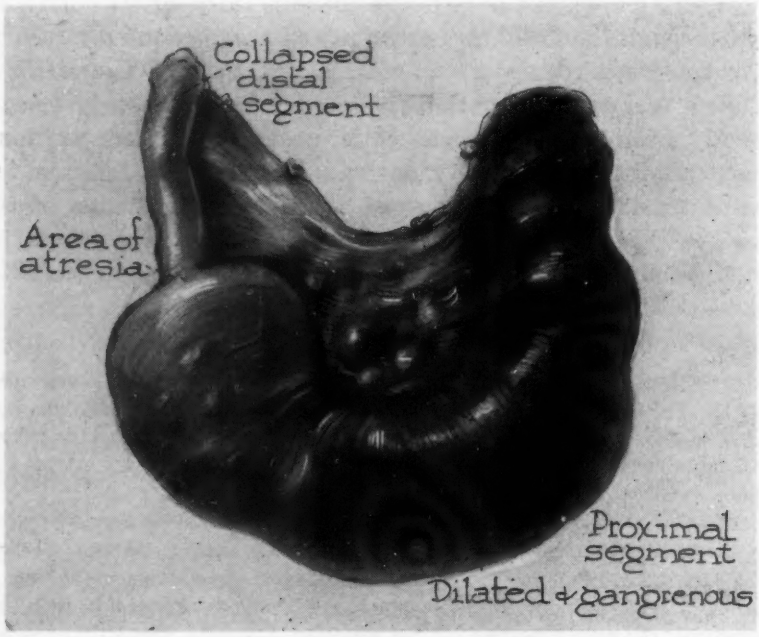

Fig. 1.—Drawing made from actual photograph of ileal atresia in infant 2 days old. A section of normal bowel has been included with area of atresia. Note gangrenous portion of ileum. The impracticality of effecting primary anastomosis between the dilated proximal segment and the contracted distal segment is apparent.

On April 2, 1946, the incision was reopened. The proximal bowel was well decompressed, nonedematous, and of good tone. The ileostomy site was resected and an open side-to-side ileo-ileostomy was done. An inner row of chromic No. 000 catgut and an outer row of No. 80 cotton vertical mattress sutures were used.

Postoperatively, the patient received parenteral infusions and blood transfusions. Intermittent gastric suction through a small Levine tube was applied. Peristalsis returned on the first postoperative day. On the third postoperative day the patient had a small, yellow, soft bowel movement. A skim milk formula and water by mouth were started. Subsequently, the course was uneventful. The abdominal wound healed without infection.

The baby was followed for a period of eight months. He was active and showed normal development. He had neither gastrointestinal symptoms nor any illnesses after discharge.

TABLE I. REPORTED CASES OF ATRESIA OF THE SMALL INTESTINE SUCCESSFULLY TREATED (MODIFIED FROM CORKILL AND CORKILL[3])

DATE	AUTHOR	COUNTRY	SITE OF ATRESIA	OPERATION	PATIENT'S AGE (DAYS)
1911	Fockens	Holland	Mid-ileal	Side-to-side ileo-ileostomy	8
1916	Ernst	Denmark	Duodenal (ampulla)	Antecolic duodeno-jejunostomy	11
1916	Weeks, Delport, & Buckert	U. S. A.	Third portion of duodenum	Posterior gastro-enterostomy	4
1924	Cutler	U. S. A.	Duodenal	Anterior gastro-enterostomy	4
	Porter & Carter	U. S. A.	Duodenal	Anterior gastro-enterostomy	9
	Stewart	England	Duodenal		
1926	Sweet & Carrier	New Zealand	High jejunum	Anterior gastro-enterostomy	9
1927	Demmer	Austria	Ileocecal	Ileocecostomy	2
1933	Corkill	New Zealand	Mid-ileal		
1933	Ladd	U. S. A.	Ileal	Ileostomy	
	Ladd	U. S. A.	Ileal	Ileostomy followed by ileocolostomy	
1945	Martin[4]	U. S. A.	Low ileal	Ileostomy with crushing of spur & later closure of ileostomy	3
1946	Lyons & Brunazzi	U. S. A.	Low ileal	Ileostomy followed by side to side ileostomy	2

SUMMARY

A case of successfully managed congenital atresia of the terminal ileum with volvulus in a newborn infant has been recorded. Initial surgical treatment was limited to resection of the proximal gangrenous loop of ileum and the segment of ileal atresia with establishment of a double-barreled ileostomy. As a secondary, or reparative, surgical procedure, the distinctive feature of management was restoration of continuity of the ileum at the time of first ileal drainage of succus entericus on the fourth day. Systemic penicillin therapy is considered to have contributed to successful abortion of the impending peritonitis. It is suggested that the interval between initial and reparative surgical treatment could be utilized to demonstrate the absence of other areas of atresia in the defunctioned terminal ileum and colon. A similar general plan of management would appear applicable to other types of intestinal obstruction requiring resection of bowel in the infant.

The advice and assistance of Dr. Ralph V. Platou and Dr. N. Woody in the clinical management of this patient are gratefully acknowledged.

REFERENCES

1. Moses, E.: Atresia of the Terminal Portion of the Ileum, With Perforation, in a Premature Infant, Am. J. Dis. Child. **62**: 141-143, 1941.
2. Ladd, W. E.: Congenital Obstruction of the Duodenum in Children, New England J. Med. **206**: 277-283, 1932.
3. Corkill, T. F., and Corkill, H. K.: Congenital Atresia of the Ileum, Australian & New Zealand J. Surg. **3**: 352-359, 1934.
4. Martin, G.: Personal Communication.

RESECTION OF THE HEAD OF THE PANCREAS AND DUODENUM FOR MULTIPLE PANCREATIC CALCULI

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UNTIL recently pancreatic calculi have been treated surgically by local excision. This treatment is satisfactory when the calculi lie in the major ducts and are easily accessible. In some cases there is a diffuse involvement of the ducts or a general calcification involving a portion or all of the pancreas. In such cases partial or total pancreatectomy is necessary to eradicate the disease.

Clagett,[1] in 1946, recorded the first case of total pancreatectomy for extensive calcareous deposits involving the entire pancreas. In a discussion of resection of the head of the pancreas for carcinoma, published in August, 1946, Waugh and Clagett[2] mentioned a case of resection of the head of the pancreas for calcification. In November, 1946, Nuzum[3] described a case of calcification of the pancreas treated by excision of the distal two-thirds of the gland. In December, 1946, Whipple[4] discussed pancreatic fibrosis associated with calcareous deposits and reported upon five patients treated by partial or complete pancreatectomy. He also included a case of total pancreatectomy reported to him personally by Zinninger.[5] In these reports there is a total of nine cases of radical resection or excision of the pancreas to which we add one case of resection of the doudenum and head of the pancreas for multiple calculi (Table I).

CASE REPORT

J. H. R., a white man, aged 45 years, was admitted to the University of Kansas Hospitals Oct. 27, 1946, complaining of upper abdominal pain.

History.—For nine years this patient had episodes of upper abdominal pain which recurred about every three or four months and usually lasted from seven to ten days. The pain was of a persistent, dull type, and was relieved only by morphine. During the attacks there was anorexia and constipation but at no time was there any nausea, vomiting, or jaundice. During the first attack of pain an appendectomy was done without relief. Two years before admission to this hospital an exploration was done and a mass was found in the region of head of the pancreas which was not diagnosed. During the nine-year period the patient gradually lost about twenty pounds in weight.

Examination.—The findings on physical examination were essentially normal with the exception of some abdominal tenderness in the epigastrium, two abdominal scars, and a questionable mass which could be felt above the umbilicus. The blood amylase was 116 mg. (Somogyi), blood sugar 80 mg., serum lipase 2 units (Cherry and Crandall), and total protein 5.3 grams. The total fat in the stool was 27 per cent. The glucose tolerance test was normal. X-ray of the upper abdomen showed numerous calcified areas in the head of the pancreas (Figs. 1 and 2).

Operation.—The date of the operation was Nov. 1, 1946. A transverse incision was made. Many adhesions were encountered as a result of the former operation. The pancreas was about twice its normal size and was very firm and nodular throughout its length. An effort was made to locate the stones in the pancreatic ducts without success.

It was then decided to remove the head of the pancreas. The technique suggested by Child[6] was used for the resection (Fig. 3). The head of the pancreas, duodenum, pyloric end of the stomach, and 15 cm. of the jejunum were excised in one mass. The distal end of the jejunum was passed through the mesentery of the colon and an end-to-end anastomosis was

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TABLE I. SUMMARY OF RECORDED CASES OF PARTIAL OR COMPLETE PANCREATECTOMY

AUTHOR	YEAR REPORTED	AGE	SEX	PATHOLOGY	OPERATION	RESULTS
1. Clagett	1946	37	F	Chronic pancreatitis with calcification	Total pancreatectomy, splenectomy and partial duodenectomy	Died of hypoglycemia 2½ mo. after operation
2. Waugh and Clagett	1946	?	?	Calcification of head of pancreas	Resection of head of pancreas	?
3. Nuzum	1946	23	M	Diffuse calcification of pancreas, cysts and fibrosis	Resection of distal two-thirds of pancreas	Uneventful recovery from operation
4. Zinninger (Whipple)	1946	39	M	Chronic pancreatitis with pancreatic lithiasis	Total pancreatectomy	Died 30 hr. after operation
5. Whipple	1946	42	M	Calculi in ducts and extreme fibrosis of parenchyma	Resection of head of pancreas, duodenum, 12 cm. of jejunum, and antrum of stomach	Condition good 3 yr. after operation
6. Whipple	1946	45	M	Calculi in ducts and chronic fibrous pancreatitis	Resection of head and part of body of pancreas, pylorus, doudenum, and 10 cm. of jejunum	Condition good 3 yr. after operation
7. Whipple	1946	45	M	Calcification and fibrosis of pancreas	Resection of duodenum, pylorus, 6 or 7 cm. of jejunum, and all of pancreas except narrow strip over mesenteric vessels	Free from pain 20 mo. after operation; taking 10-15 units of insulin
8. Whipple	1946	26	F	Pancreatic calculi, fibrosis and dilated ducts	Total pancreatectomy, duodenectomy, pylorectomy	1 yr. after operation in tuberculosis sanatorium; takes 84 units zinc insulin
9. Whipple	1946	46	F	Pancreatic calculi, dilated ducts, and fibrosis	Total pancreatectomy, duodenectomy, pylorectomy, and splenectomy	Died on seventh postoperative day
10. Leopard and Orr	1947	45	M	Chronic cystic pancreatitis, fibrosis, and pancreatic calculi	Resection of head of pancreas, pylorus, duodenum, and 15 cm. of jejunum	Condition good 4½ mo. after operation; has returned to regular occupation

made between the stump of the pancreas and the open end of the jejunum, using two rows of interrupted silk sutures. The common duct was next anastomosed to the jejunum about 5 cm. distal to the first anastomosis. This was done with an inside row of catgut sutures and an outside row of interrupted silk sutures. A gastrojejunostomy was made about 10 cm.

distal to the gall duct anastomosis, using an inside row of catgut sutures and an outside row of interrupted silk sutures. The jejunum and its mesentery were sutured to the mesocolon to prevent herniation. The abdominal wound was closed with silk. A drain was passed down to the right of the common duct which emerged at the right end of the incision. This patient made a very good recovery and was dismissed from the hospital on the thirteenth postoperative day.

Pathology.—Chronic cystic pancreatitis, fibrosis, and multiple pancreatic calculi were found.

Fig. 1.—Radiograph showing calculi in head of pancreas.

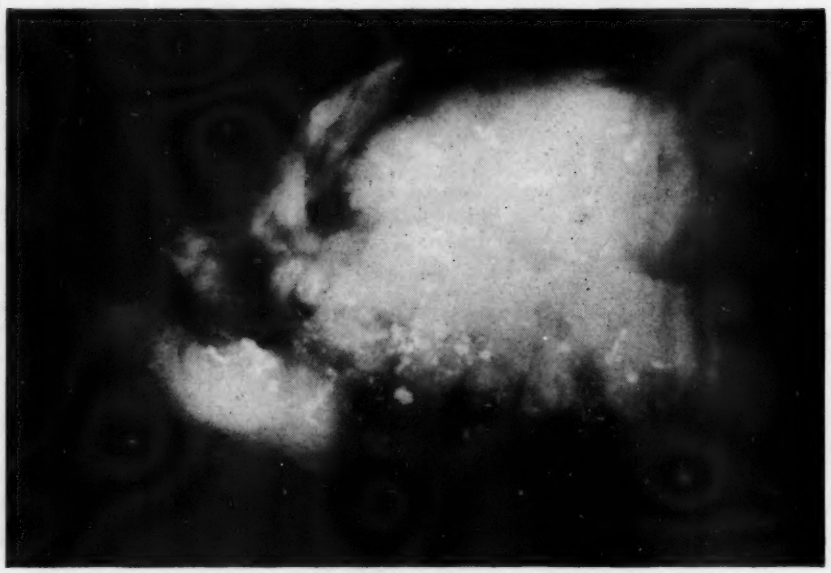

Fig. 2.—Radiograph of resected head of pancreas.

Follow-up.—After leaving the hospital this patient had an attack of fever which was apparently due to cholangitis. He recovered rapidly and returned to work seven weeks after operation. On March 15, 1947, four and one-half months after operation, he was free from pain and working full time at his occupation.

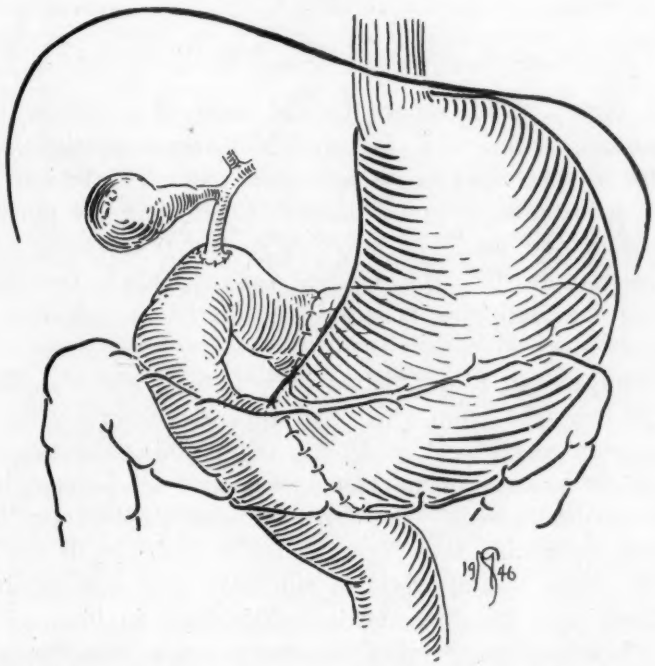

Fig. 3.—Completed operation showing end-to-end pancreaticojejunostomy, end-to-side choledochojejunostomy, and end-to-side gastrojejunostomy.

SUMMARY

Certain cases of extensive involvement of the pancreatic ducts with calculi or diffuse calcification of the pancreas, causing intractable pain, may be successfully treated by partial or complete pancreatectomy. The results thus far published indicate that both partial and complete pancreatectomy are well tolerated. The hyperglycemia resulting from complete pancreatectomy can be controlled by insulin. It is suggested that postoperative ascending biliary duct infection, which sometimes develops as a result of duodenectomy, may be reduced to a minimum by increasing the distance between the choledochojejunostomy and the gastrojejunostomy.

REFERENCES

1. Clagett, O. T.: Total Pancreatectomy: A Symposium Presenting Four Successful Cases, With Metabolic Studies, Proc. Staff Meet., Mayo Clin. **21**: 25, 1946.
2. Waugh, J. M., and Clagett, O. T.: Resection of the Duodenum and Head of the Pancreas for Carcinoma, SURGERY **20**: 224, 1946.
3. Nuzum, F.: Diffuse Calcification of the Pancreas, J. A. M. A. **132**: 574, 1946.
4. Whipple, A. O.: Radical Surgery for Certain Cases of Pancreatic Fibrosis Associated With Calcareous Deposits, Ann. Surg. **124**: 991, 1946.
5. Zinninger, M. M.: Reported by Whipple as a Personal Communication, Ann. Surg. **124**: 991, 1946.
6. Child, C. G.: Pancreaticojejunostomy and Other Problems Associated With the Surgical Management of Carcinoma Involving the Head of the Pancreas, Ann. Surg. **119**: 845, 1944.

POSTAPPENDECTOMY INCISIONAL INTERSTITIAL INGUINAL HERNIA

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FISHER, in March, 1946, reported eight cases of postappendectomy interstitial inguinal hernia. All followed McBurney incisions, and all were "false" hernias in that none had a peritoneal sac. The herniating structure, omentum in each instance, emerged through a defect in the peritoneum of the McBurney incision and made its way under the transversus abdominis and internal oblique muscles into the inguinal canal. This it traversed to present at the external inguinal ring where it simulated an inguinal hernia upon clinical examination.

The following month I was visited by a patient who complained of a reducible bulge in the right groin which had appeared shortly after an appendectomy with drainage performed in 1936. On examination there was a well-healed right lower rectus appendectomy scar and an independent, reducible right indirect inguinal hernia. Because of Fisher's recent article I examined the patient with particular care for evidence of a defect at the lower end of the rectus scar. None was appreciable clinically so it was concluded that the lesion was an ordinary inguinal hernia, particularly in view of the fact that the patient had had complete relief for many years from the wearing of an ordinary inguinal truss. The frequent occurrence of inguinal hernias following appendectomy had been noted by Hoguet and by Watson, who attributed the occurrence to a weakening of the abdominal wall produced by injury of the nerve supply of the muscles of the internal ring, usually the iliohypogastric and sometimes the ilioinguinal nerves.

At operation, the hernia proved to be of a variety hitherto undescribed. A true incisional hernia was found which descended from the lower end of the rectus scar behind the rectus and internal oblique muscles to enter the inguinal canal, which it traversed to make its exit through the external inguinal ring. While related to those reported by Fisher, it differed from them in that it was a true hernia, completely enclosed in a peritoneal sac, and it made its way to the inguinal canal from a right rectus incision rather than from a McBurney incision as in the cases he reported. While it is likely that such hernias have been encountered by others, I was unable to find any such in the literature and hence feel a report is warranted.

CASE REPORT

H. F., a 38-year-old man, was seen for the first time on April 10, 1946, at which time he complained of a reducible lump in the right groin. This had been noted first shortly after appendectomy with drainage in 1936. At first, it was relatively asymptomatic; later it caused moderate discomfort for which a truss was prescribed. This held the hernia effectively reduced, and was worn with relief of symptoms for approximately nine years. How-

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ever, because of the nuisance involved in wearing a truss and local irritation produced by it, he now desired operative correction. There was a history of bleeding peptic ulcer four years previously, but now he was asymptomatic in this regard and x-ray views of the stomach and duodenum taken recently were negative. There was no other significant history.

Physical examination revealed an apprehensive, slightly built adult man with no significant findings apart from the local lesion, where what seemed to be a typical indirect inguinal hernia protruded through the external inguinal ring, descending as far as the upper portion of the scrotum. The hernia was readily reducible and, when reduced, pressure upon the internal inguinal ring maintained reduction through coughing or straining. When pressure upon the internal ring was released, the hernia again promptly desceded into the canal and out the external ring. The possibility of an interstitial incisional hernia was considered and the right lower rectus appendectomy scar was examined carefully with this in mind. However, no evidence of deficiency, weakness, or abnormal impulse could be detected along the length of the scar, which seemed solid in its entirety. Accordingly, the lesion was considered to be an ordinary indirect inguinal hernia, anatomically independent of the previous operative site.

The patient was admitted to The Mount Sinai Hospital May 5, 1946 (No. 548586) and was operated upon May 6. An inguinal incision was made and the external oblique aponeurosis was incised in the direction of its fibers through the external ring. The lower leaf of the aponeurosis of the external oblique was dissected free to expose Poupart's ligament and the upper leaf retracted upward to expose the spermatic cord emerging from beneath the internal oblique muscle. The cremaster fascia was incised and the hernial sac overlying the spermatic cord anterosuperiorly was identified. The sac was opened and a nubbin of omentum which it contained was reduced into the peritoneal cavity. Traction was made upon the sac by a finger placed within it, and dissection of the sac from the cord structures was proceeded with. As the dissection was carried proximally, the sac was observed to diverge superomedially from the cord structures in the region of the internal ring. Moreover, it was now recognized that nowhere in its extent had the sac been as closely applied to the cord structures as is ordinarily the case, and a suspicion that an unusual variety of hernia was being encountered, possibly an incisional interstitial hernia which had not been discernible clinically, now began to make itself felt. Further examination in the region of the internal ring revealed that the sac not only actually diverged superomedially from the cord structures at this point, but that it extended as a tubular sac for a considerable distance above this level. Accordingly, the internal oblique and transversus abdominis muscles were divided vertically and the sac was then easily followed in a course leading at first behind the internal oblique muscle and then behind the rectus abdominis to the lower end of the old appendectomy scar where it was seen to emerge from a deficiency in the transversalis fascia. At this point the sac was transfixed and the excess cut away. The transversalis fascia was closed over the stump. The internal oblique and transversus abdominis muscles were repaired with interrupted sutures. The cord was delivered and the transversalis fascia overlying the direct space and the internal ring were plicated as there seemed to be some loss of normal tautness in these areas. The upper leaf of the external oblique aponeurosis was brought down to the shelving edge of Poupart's ligament and the lower leaf was overlapped across the suture line with subcutaneous transplantation of the cord. The skin was closed with Michel clips.

The postoperative course was entirely uneventful and the patient was discharged with primary healing on the eleventh postoperative day. He was seen for a checkup on Dec. 11, 1946, at which time he had no complaints and the wound was solidly healed with no evidence of recurrence or weakness.

COMMENT

Hernias develop interstitially when that is the least resistant path to take. Thus, the ordinary interstitial inguinal hernia is most commonly found in association with an undescended testicle, in which case the preformed processus vaginalis no longer leads to the scrotum, and hence eliminates this as the path of least resistance. In Fisher's cases, the pathway between a McBurney in-

cision and the inguinal canal is obviously an easy one to traverse as a moment's reflection on the anatomy will show. Actually, a herniation through a defect in the transversalis fascia at the lower angle of a McBurney incision is practically within the inguinal canal since it is situated posterior to the internal oblique muscle which forms the anterior wall of the inguinal canal, and anterior to the transversalis fascia which forms the posterior wall of the canal. To enter the canal itself it needs only to travel a short distance inferiorly in a preformed fascial plane, a pathway which should offer little resistance. Hence, such an occurrence should not be uncommon and it is surprising that there is no record of it prior to Fisher's report.

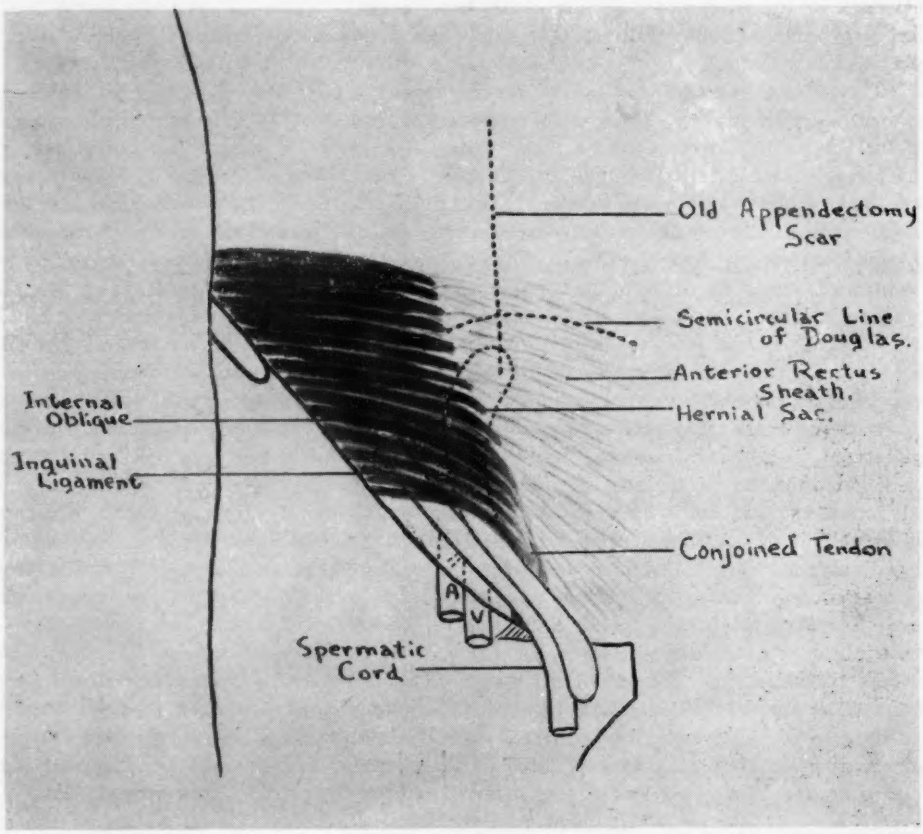

Fig. 1.—Diagram showing relationship of incisional hernial sac to inguinal canal and spermatic cord.

The pathway in the case reported here does not differ substantially from those in Fisher's cases despite the origin of the hernia from the lower angle of a right rectus incision. In brief, the pathogenesis was as follows (Fig. 1). A defect in the transversalis fascia doubtless was present at the drainage site at the lower angle of the right rectus incision. This was below the level of the linea semi-circularis of Douglas. Arising at this point, the peritoneal sac pushed through the defect in the transversalis fascia to lie between it and the rectus abdominis muscle. As the sac developed, this plane offered the least resistant

pathway, and it pushed its way inferolaterally in a course leading first behind the rectus abdominis muscle and then behind the internal oblique (and transversus abdominis). Once behind the internal oblique its location was the same as in Fisher's cases and entrance into the inguinal canal occurred in identical manner by further downward extension. A crucial point in the pathway the hernia took is the origin of the sac below the level of the line of Douglas. Below this level the rectus muscle lacks a posterior sheath, and accordingly no fusion of anterior and posterior sheaths at the lateral border of the rectus exists to prevent the crossing of this border by the hernia. Also, since the outer border of the rectus curves inward below the level of the line of Douglas, an almost directly downward course of the hernial sac will carry it across the lateral rectus border to a position behind the internal oblique. Therefore, a natural fascial pathway is seen to exist along which a hernia developing at the inferior angle of a right lower rectus incision can easily pass to enter the inguinal canal.

The case reported was a true hernia in that it possessed a complete peritoneal sac, differing in this respect from Fisher's cases. A common fascial covering enveloped both the sac and the spermatic cord which was presumed to be cremaster fascia acquired from the internal oblique muscle as the sac entered the inguinal canal, in the same manner as the spermatic cord acquires its covering of cremaster fascia. However, the common covering may merely have been adventitial tissue developing over the nine-year period that the hernia existed and the truss was worn.

It is of interest that no sign of origin from the old incision could be detected clinically even though this was specifically sought. The clinical findings were those of an ordinary indirect inguinal hernia. The importance of this surgically is obvious, as a cure will not be obtained unless the true nature of the hernia is recognized at the operating table.

SUMMARY

1. A case of a hitherto undescribed variety of hernia is reported. The hernia, a postappendectomy, incisional, interstitial, inguinal hernia, descended from the lower angle of a right lower rectus incision posterior to the rectus and internal oblique (and transversus abdominis) muscles to enter the inguinal canal, which it then traversed.

2. On clinical examination what appeared to be a typical reducible indirect inguinal hernia was found, extending through the external inguinal ring into the upper scrotum. The right rectus scar appeared to be solid and the hernia independent of it. Only at operation was the true relationship discovered.

3. The pathogenesis of such a hernia is discussed and the importance of recognizing its true nature is stressed.

REFERENCES

1. Fisher, H. C.: Postappendicectomy Interstitial Inguinal Hernia, Ann. Surg. 123: 419, 1946.
2. Hoguet, J. P.: Right Inguinal Hernia Following Appendicectomy, Ann. Surg. 54: 673, 1911.
3. Watson, L. F.: Hernia, ed. 2, St. Louis, 1938, The C. V. Mosby Company.

Recent Advances in Surgery

CONDUCTED BY ALFRED BLALOCK, M.D.

II. RENAL FUNCTION STUDIES IN THE WOUNDED

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INTRODUCTION

THE desirability of measuring renal function as accurately as possible in the wounded was clear at the outset of this study. In the majority of cases phenolsulfonphthalein excretory capacity and urine concentration tests where possible (in conjunction with routine urinalyses and blood chemistry determinations) were used as a means of estimating renal function. Mannitol and sodium para-amino hippurate for the estimation of glomerular filtration rate, effective renal blood flow, and maximal tubular excretory capacity did not become available to us until the last weeks of the Italian campaign. The results of the phenolsulfonphthalein, urine concentration, and the few clearance tests performed will be described.

PHENOLSULFONPHTHALEIN EXCRETORY CAPACITY

Practical considerations prevented estimating phenolsulfonphthalein excretory capacity until after operation; all of the measurements were made postoperatively (or, in the few cases which had no surgery, after the patients had been transferred from the shock ward), and usually many hours after adequate resuscitation had been effected. Two main groups are included: (1) that in which the test was done within seventy-two hours after wounding, and (2) that in which it was repeated after the third day if initial excretory capacity was impaired, in order to follow the rate of recovery. Included in the latter group are three patients in whom initial phenolsulfonphthalein tests were done later than the third day after wounding, but in whom the quantity of dye excreted was low.

Technique of Test.—The following technique of performing this test was commonly employed. Six milligrams of phenolsulfonphthalein were injected intravenously and urine collections made 15, 30, 60, and 120 minutes later.

This paper is published with minor changes from "The Physiological Effects of Wounds," a report of The Board for the Study of the Severely Wounded, by the same authors (Government Printing Office, 1948).

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It was necessary to use an indwelling catheter in practically every case to insure accurate collection. Oral intake of fluid was restricted in most patients at the time the test was performed; therefore, in order to promote urine flow, a liter of 5 per cent glucose in normal saline solution or 10 per cent glucose in distilled water was frequently started intravenously about one-half hour before injection of the dye.

Excretory Capacity in the First Three Days After Wounding.—The average results of the test and other pertinent data in 57 cases* during this period are shown in Table I and Fig. 1.

The most striking feature is the difference between the percentages of dye excreted by the 20 patients with no shock and the percentages of dye excreted by the 37 patients with slight, moderate, and severe shock. Average excretion during all periods was normal in the no-shock group (see discussion to follow on relation to type and duration of anesthesia in this group). During the first half hour, excretion was low in all patients with initial shock, and was lower with increasing severity of shock. Although standard errors of the mean are rather large, and although there are no significant differences among the three groups with slight, moderate, or severe shock, the qualitative variations are evident. After the first half hour, average dye excretion became normal in all patients except the 14 with severe initial shock. In these 14 patients the average excretion was significantly less than normal even after two hours.

The total amount and rapidity of dye excretion are well correlated with average nonprotein nitrogen values determined on the same days the dye was given, as shown by the higher average nonprotein nitrogen values in each group according to severity of shock (see Table I). Likewise, the number of cases with "high azotemia," oliguria, or anuria rises with increasing severity of shock.†

Incidence of initial hypotension (systolic blood pressure 80 mm. of mercury or less) increases with severity of shock; 25 or 26 patients with severe or moderate shock had low blood pressure during the period of shock.

Effect of Anesthesia.—One might argue that the diminished ability to excrete phenolsulfonphthalein in these cases was largely or partially due to the effect of anesthesia, especially ether. Our data indicate that this is not true. In the 20 patients with no shock, and in whom phenolsulfonphthalein excretion was normal (Table 1 and Fig. 1), the anesthetic agents employed were as follows: ether alone, 3 cases; pentothal alone, 1 case; pentothal induction followed by ether, 16 cases. The average length of anesthesia in these 20 was 1.69 ± 0.21 hours; the phenolsulfonphthalein test was started, on the average, 8.39 ± 1.28 hours after anesthesia was ended. If ether per se had any marked effect

*Twenty-one of these are not included in our total series of 186 patients.[1] They were collected merely to enlarge the series of phenolsulfonphthalein tests, without attempting to do complete studies. Seventeen of the 21 had no shock; 1, slight shock; and 2, moderate shock.

†The "high azotemia" group includes all patients whose nonprotein nitrogen rose to 65 mg. per cent or higher at some time during the post-traumatic period. The oliguria group includes patients with a twenty-four hour urine output of 100 to 600 c.c. at least once during the post-traumatic period. The anuria group includes patients with a urine output of less than 100 c.c. daily.

TABLE I

DEGREE OF INITIAL SHOCK	TOTAL NUMBER OF CASES*	PHENOLSULFONPHTHALEIN EXCRETION—AVERAGES IN PERCENTAGE INCREMENTS				HOURS FROM WOUNDING TO TEST (AVERAGE)	N.P.N. ON DAY OF TEST (AV. MG. %)	"HIGH AZOTEMIA" (NUMBER OF CASES)	OLIGURIA OR ANURIA (NUMBER OF CASES)	INITIAL HYPOTENSION† (NUMBER OF CASES)
		15 MIN.	30 MIN.	60 MIN.	120 MIN.					
None	20	31.6 ±2.47	50.5 ±2.57	64.9 ±2.86	73.3 ±2.82	19.05 ±1.55 (Max. 44)	28 ±1.2	0	1	0
Slight	11	16.86 ±3.43	34.55 ±4.66	51.45 ±5.68	61.0 ±5.8	30.64 ±4.54 (Max. 66)	31.18 ±2.04	0	3	2
Moderate	12	12.75 ±2.77	33.25 ±5.56	49.08 ±7.12	66.08 ±7.73	31.25 ±3.22 (Max. 46)	43.08 ±4.44	3	4	11
Severe	14 †	9.66 ±3.42	25.22 ±6.42	36.38 ±8.66	43.62 ±9.6	37.4 ±3.05 (Max. 60)	47.8 ±4.2	7	8	14

Standard errors of the mean are shown.

*Includes one crush patient, who was not operated on; all other tests were done postoperatively.

†Blood pressure 80 mm. Hg or less.

upon dye excretion, it should be evident in this group in which shock and hypotension were absent. Further evidence that anesthesia did not affect the ability of the kidneys to excrete phenolsulfonphthalein in this series is that the average time between wounding (and hence in most cases between anesthesia) and determination of excretory capacity was considerably greater in those cases which showed greatest diminution of excretory capacity (Table I). Ether was used in all 37 patients with diminished excretion and coincident varying degrees of shock, except one patient with a crushing injury who had no anesthesia.

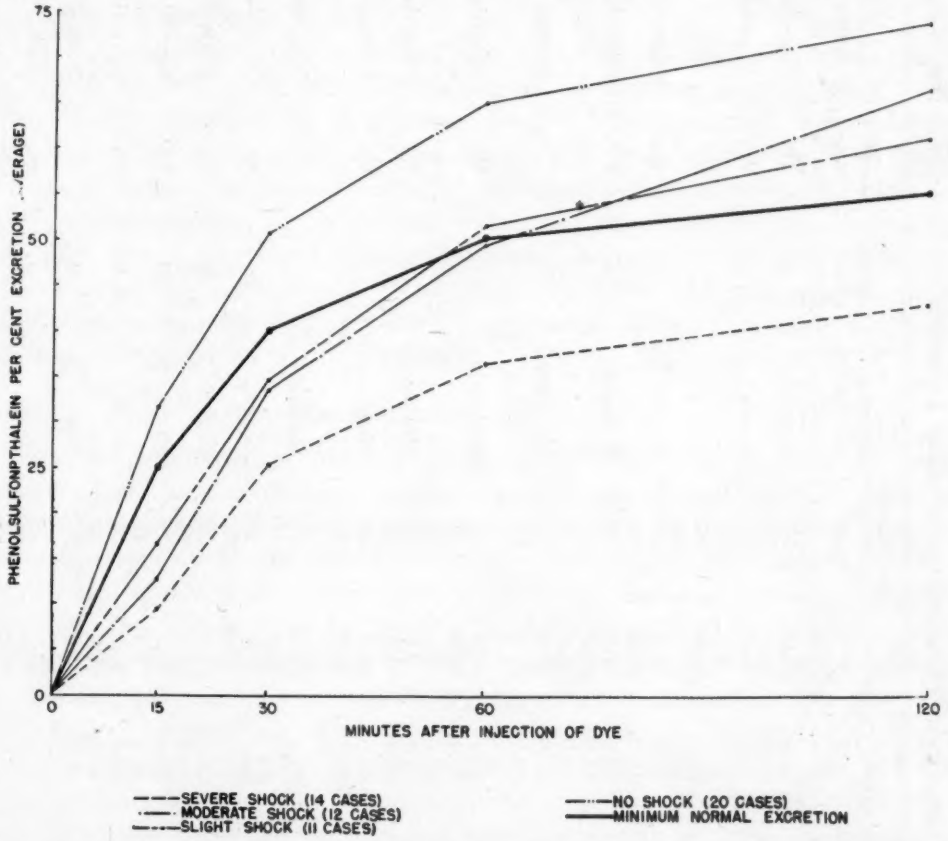

Fig. 1.—Average phenolsulfonphthalein excretory capacity in 57 wounded patients classified according to degree of initial shock. Increments of percentage of phenolsulfonphthalien excreted are represented. Observations are discussed in the text. (Minimum normal excretion statistics from Stitt, Clough, and Clough.[6])

Rate of Recovery of Phenolsulfonphthalein Excretory Capacity.—For those interested in details, Table II is included, showing phenolsulfonphthalein excretion and other pertinent data on 15 patients in whom the test was repeated one or more times.

Table II shows that of 15 patients in whom the test was done on the fourth or fifth postoperative day, 7 had normal excretion. All of these 7 had abnormal excretion during the first three days after wounding; 2 had moderate initial shock; 3, slight shock; and 2, no shock. Of the 8 patients in whom dye excretion was low on the fourth or fifth postoperative days, 3 had undergone the test

TABLE II. RATE OF RECOVERY OF PHENOLSULFONPHTHALEIN EXCRETORY CAPACITY FOLLOWING WOUNDING

CASE NUMBER	TIME, WOUNDING TO TEST	PHENOLSULFONPHTHALEIN EXCRETION (PERCENTAGE)				N.P.N. ON DAY OF TEST (MG. %)	DEGREE OF INITIAL SHOCK	INITIAL HYPOTENSION	"HIGH AZOTEMIA"	URINE OUTPUT	REMARKS
		15 MIN.	30 MIN.	60 MIN.	120 MIN.						
81	39 hr.	03	2.0	14.0	25.0	77	Severe	++	Yes	Oliguria	Uneventful recovery
	5 days	4.0	19.0	33.0	55.0	56					
60	24 hr.	0.3	1.3	2.0	3.5	58	Severe	++	Yes	Oliguria	Recovery diuresis
	4 days	1.0	2.0	3.0	5.0	108					
	9 days	6.0	18.0	25.0	34.0	46					
	12 days	21.0	31.0	43.0	52.0	33					
125	4 days	3.0	6.0	10.0	15.0	108	Severe	+	Yes	Oliguria	Recovery diuresis
	14 days	3.0	7.0	18.0	27.0	65					
104	5 days	23.0	33.0	47.0	57.0	44	Moderate	+	Yes	Oliguria	Recovery diuresis
	7 days	5.0	9.0	14.0	30.0	29					
	11 days	42.0	56.0	69.0	78.0	29					
107	23 hr.	6.0	15.0	21.0	28.0	41	Moderate	++	Yes	Normal	Died 6th day; alkalosis uremia contributory
	5 days	0.8	1.2	3.0	17.0	73					
63	24 hr.	3.0	18.0	38.0	63.0	43	Moderate	++	No	Oliguria	Uneventful recovery
	4 days	2.0	6.0	31.0	39.0	31					
	8 days	21.0	44.0	62.0	73.0	25					
1	37 hr.	0.0	0.0	2.0	16.0	54	Moderate	+	No	Oliguria	Uneventful recovery
	4 days	43.0	56.0	69.0	79.0	36					
29	4 days	0.0	11.0	40.0	59.0	49	Moderate	+	Yes	Oliguria	Stormy course; probable blood stream infection
	5 days	25.0	41.0	61.0	75.0	46					
53	31 hr.	8.0	15.0	27.0	56.0	37	Moderate	+	No	Oliguria	Uneventful recovery
	4 days	34.0	48.0	63.0	73.0	27					
15	24 hr.	23.0	42.0	55.0	70.0	36	Slight	+	No	Oliguria	Uneventful recovery
	4 days	47.0	63.0	73.0	77.0	31					
83	23 hr.	6.5	23.0	36.0	44.0	26	Slight	0	No	Normal	Uneventful recovery
	4 days	55.0	69.0	78.0	89.0	24					
111	14 hr.	7.0	34.0	68.0	74.0	30	Slight	0	No	Normal	Uneventful recovery
	5 days	41.0	43.0	71.0	74.0	48					
128	30 hr.	16.0	19.0	39.0	40.0	31	Slight	0	No	Normal	Uneventful recovery
	5 days	22.0	23.0	43.0	45.0	39					
106	16 hr.	20.0	47.0	67.0	73.0	24	None	0	No	Normal	Uneventful recovery
	4 days	40.0	57.0	73.0	81.0	--					
102	15 hr.	18.0	28.0	48.0	53.0	43	None	0	No	Normal	Uneventful recovery
	5 days	42.0	64.0	76.0	84.0	--					

for the first time during this period, and 5 are known to have had diminished excretion during the first three days. Of these 8 patients, the degree of initial shock was slight in one, moderate in 4, and severe in 3. Three cases conformed with the syndrome of recovery diuresis.

The test was repeated between the eighth and fourteenth days in 4 patients. One had normal dye excretion by the eleventh day. Another had slightly diminished excretion during only the first fifteen minutes on the eighth day. Two who had recovery diuresis still had abnormal excretion on the twelfth and fourteenth postoperative days, respectively.

With the exception of one patient who died with alkalosis and renal failure (Case 107, Table II), all patients in whom initial test results were low showed improved dye excretion as tests were repeated. Improvement was reflected chiefly in ability to excrete increased amounts of dye during the first thirty minutes, although total amount excreted increased also with passage of time.

The time required for phenolsulfonphthalein excretory capacity to return to normal is well correlated with urine output, nonprotein nitrogen retention, and degree of initial shock and hypotension (see Table II). In general, those with normal urine output or only slight suppression, minimal nitrogen retention, and slight shock recovered most rapidly.

RENAL CLEARANCE STUDIES

The predominance of histologic changes in the lower nephron, and the paucity of glomerular damage seen in the kidneys of patients who died of this syndrome immediately raised the question of how much functional impairment corresponds with anatomic alterations.[1] One obvious approach to solution of this problem would be in utilization of clearance methods of measuring renal function. This was done in 11 patients—a small series, but the largest obtainable after the materials necessary for performance of the tests became available.

Methods.—Mannitol was used for measurement of glomerular filtration rate (C_M), sodium para-amino hippurate for effective renal plasma flow (C_{PAH}) and maximal tubular excretory capacity (Tm_{PAH}). Methods of analysis are described in a separate report.[1] Quantities given and rates of administration were essentially those suggested by Goldring and Chasis.[3] Indwelling, multiple-eyed catheters were routinely employed. The bladder was washed with 10 to 30 c.c. of physiologic saline solution at the end of each collection period, followed by 10 to 20 c.c. of air to insure complete emptying of the bladder. Protocols are included with the individual case histories and contain complete details.[1]

Types of Cases (Table III).—Five patients were studied within the first thirty-one hours after wounding but after resuscitation had been effected and operation completed. One of these had no initial shock; 1, slight; 2, moderate; and 1, severe. None had a nonprotein nitrogen of 65 mg. per cent or over, that is, "high azotemia," while we observed them. Urine output was normal throughout in 4. One patient was listed as having had oliguria in our original sense for one day (Case 142), but the oliguria was not severe, and can be disregarded since on the preceding and succeeding days urine output was satisfactory.

TABLE III. SUMMARY OF RENAL CLEARANCE STUDIES

CASE NUMBER	URINE FLOW—ALL PERIODS (C.C. PER MIN.)	FILTRATION RATE (C.C. PER MIN.)	EFFECTIVE PLASMA FLOW (C.C. PER MIN.)	EFFECTIVE BLOOD FLOW (C.C. PER MIN.)	TmPAH (MG. PER MIN.)	FILTRATION FRACTION	CPAH/TmPAH	CM/TmPAH	TIME OF RENAL CLEARANCE AFTER WOUNDING	DEGREE OF INITIAL SHOCK	"HIGH AZOTEMIA"	N.P.N. ON DAY OF TEST (MG. %)	URINE OUTPUT	URINE OUTPUT ON DAY OF TEST (C.C.)	BLOOD PRESSURE ON DAY OF TEST	OUTCOME
134	3.6	95	588	1071	84	0.15	5.8	0.84	29 hr.	None	No	43	Normal	1635	114/65	Recovery
	(3)	(2)	(1)	(1)	(1)	(1)	(1)	(1)								
141	4.8	167	762	1093	56	0.19	12.3	2.50	19 hr.	Slight	No	41	Normal	2420	120/80	Recovery
	(4)	(4)	(2)	(2)	(2)	(2)	(2)	(2)								
142	4.8	135	754	1136	91	0.15	8.1	1.73	14 hr.	Moder-	No	27	Oliguria	1693	130/70	Recovery
	(4)	(4)	(2)	(2)	(2)	(2)	(2)	(2)		ate						
148	3.8	109	567	816	63	0.20	9.0	1.60	31 hr.	Moder-	No	40	Normal	1787	130/70	Recovery
	(4)	(4)	(2)	(2)	(2)	(2)	(2)	(2)		ate						
139	5.2	79	381	556	97	0.18	3.3	0.80	20 hr.	Severe	No	36*	Normal	3762	114/78	Recovery
	(4)	(4)	(2)	(2)	(2)	(2)	(2)	(2)								
143	3.8	89	598	1037	108	0.13	5.1	0.81	3 days	Moder-	Yes	57	Normal	1986	110/60	Uremia coincident at death, 5 days later
	(4)	(4)	(2)	(2)	(2)	(2)	(2)	(2)	14 hr.	ate						
133	2.34	20	99	163	7	0.21	13.4	2.2	11 days	Severe	Yes	108	Unknown, probably oliguria	1270+	150/110	Recovery diuresis
	(4)	(4)	(2)	(2)	(2)	(2)	(2)	(2)								

133	4.0 (3)	26 (3)							13 days	Severe	Yes	112	Unknown, probably oliguria	2380	140/110	Recovery diuresis
133	3.42 (3)	58 (3)	342 (3)	499 (3)		0.15 (3)			28 days	Severe	Yes	36	Unknown, probably oliguria	Over 1000	122/96	Recovery diuresis
133	4.33 (2)	157† (2)	688 (2)	1146 (2)		0.20 (2)			47 days	Severe	Yes	24	Unknown, probably oliguria	Over 1000	120/70	Recovery diuresis
133	9.14	107‡ (2)			90 (2)		7.62§	0.84	49 days	Severe	Yes	20	Unknown, probably oliguria	Over 1000	120/70	Recovery diuresis
147	4.1 (4)	64 (4)	356 (2)	630 (2)	70 (2)	0.21 (2)	5.0 (2)	0.91	7 days 18 hr.	Severe	Yes	99	Normal	1558	110/60	Uremia coincident at death, 16 hr. later
125	5.72 (4)	89 (4)	544 (2)	870 (2)	80 (2)	0.16 (2)	6.5 (2)	1.06 (2)	30 days	Severe	Yes	26	Oliguria	1500 ± 500	130/91	Recovery diuresis
150	4.42 (4)	15 (4)	87 (2)	131 (2)	12 (2)	0.18 (2)	7.7 (2)	1.1 (2)	14 days	Moderate	Yes	123	Anuria	3350	170/100	Recovery diuresis
150	4.74 (4)	100 (4)	414 (2)	686 (2)	67 (2)	0.24 (2)	7.7 (2)	1.2 (2)	26 days	Moderate	Yes	24	Anuria	3000±	130/70	Recovery diuresis
138	3.0 (4)	3 (4)	20 (2)	28 (2)	4 (2)	0.18 (2)	7.5 (2)	0.33 (2)	10 days	None	Yes	217	Unknown, probably oliguria	1500±	140/68	Recovery diuresis
138	5.54 (4)	64 (4)	431 (2)	676 (2)	43 (2)	0.12 (2)	8.1 (2)	1.3 (2)	26 days	None	Yes	44	Unknown, probably oliguria	4500±	128/70	Recovery diuresis
Mean normal		131 ± 21.5	697 ± 135.9	1204 ± 255.9	76	19 ± 0.0244	9.2	1.72								

Numbers in parenthesis represent number of periods averaged. Values in Columns 3 through 8 corrected to 1.73 square meters of body surface.

Normals and standard deviations from Goldring and Chasis,[3] and Smith.[5]

*One day later.

†Plasma mannitol levels below 1.0 mg. per cubic centimeter; so observed filtration rate possibly too high.

‡Only 2 of 5 periods averaged. Last 3 during glucose Tm determination fell rapidly, giving average of 89 if they are included.

§Calculated from PAH done two days previously.

The remaining 6 patients were first studied between three and thirty days after wounding. All of them had "high azotemia" at some time during their course. One had no shock; 2, moderate; and 3, severe. In 3 patients, clearances were first measured while renal failure was severe, and repeated after recovery diuresis had taken place. A fourth had severe renal failure, but

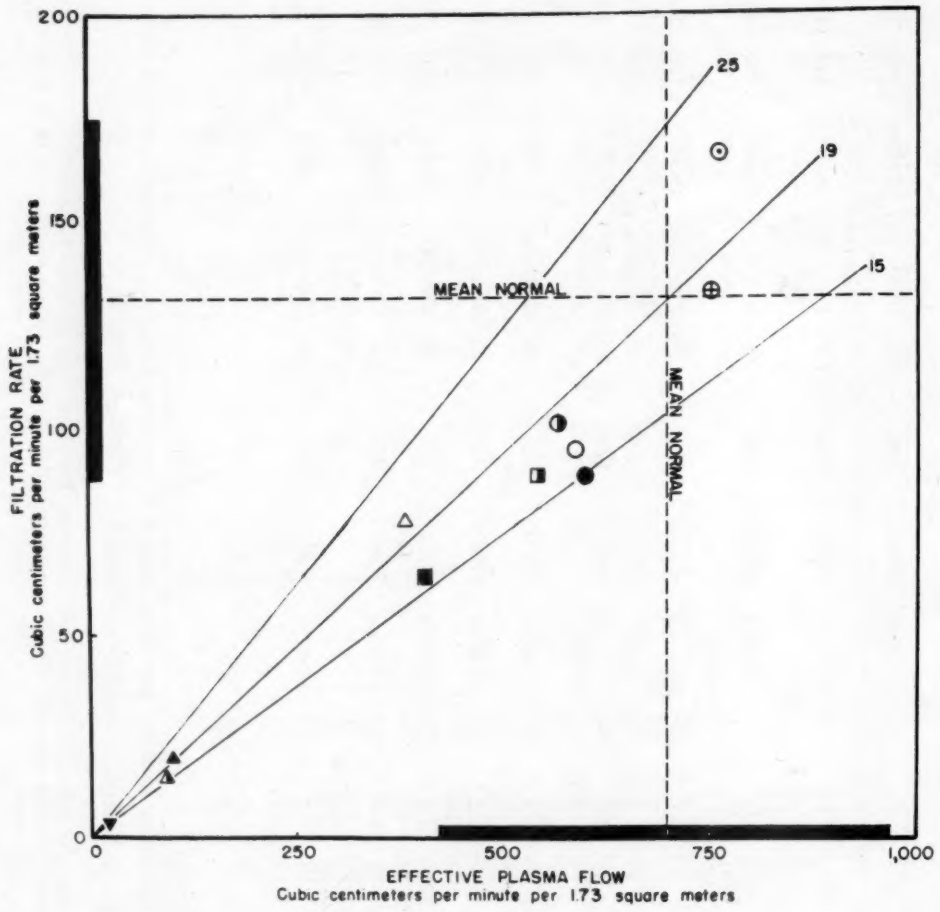
200
150
100
50
0
FILTRATION RATE
Cubic centimeters per minute per 1.73 square meters
25
19
15
MEAN NORMAL
MEAN NORMAL
0
250
500
750
1,000
EFFECTIVE PLASMA FLOW
Cubic centimeters per minute per 1.73 square meters
No shock, no azotemia, 29 hours after wounding.
Slight shock, no azotemia, 19 hours after wounding.
Moderate shock, no azotemia, 14 hours after wounding.
Moderate shock, no azotemia, 31 hours after wounding.
Severe shock, no azotemia, 20 hours after wounding.
Moderate shock, azotemia, 3 5 days after wounding
Severe shock, azotemia, 7 75 days after wounding.
Severe shock, azotemia, recovery diuresis, 30 days after wounding.
Severe shock, azotemia, recovery diuresis, 11 days after wounding.
Moderate shock, azotemia, recovery diuresis, 14 days after wounding.
No shock azotemia, recovery diuresis, 10 days after wounding.

Fig. 2.—Relationship between effective plasma flow and glomeruler filtration rate. The values reresented in this figure and in the succeeding three figures, were obtained from average values shown in Table III. Mean normals and two times the standard deviations thereform have been taken from Smith[5] (combined series, normal men, p. 71). Diagonal lines represent filtration fraction ($\frac{C_M}{C_{PAH}}$). For subsequent studies on the three patients with the lowest values, see Figs. 6, 7, and 8. See text for discussion.

clearances were not done until thirty days after wounding, by which time he had a recovery diuresis and plasma nonprotein nitrogen was normal. The remaining 2 died sixteen hours and five days, respectively, after clearance studies were done; in both cases uremia was coincident at death but not a primary or contributory cause of death.

Further pertinent details will be found in Table III and the individual case histories.[1]

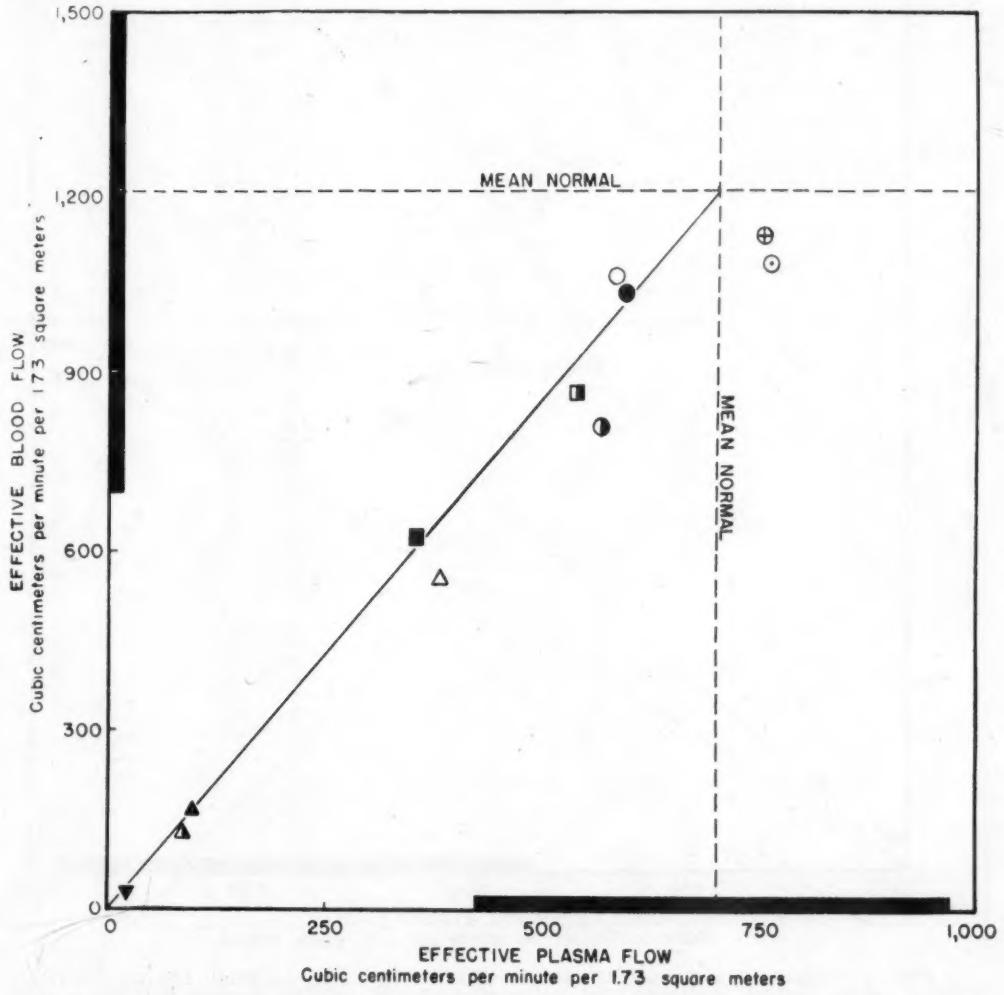

Fig. 3.—Relationship between effective plasma flow and effective blood flow. Symbols are explained in Fig. 2. Note influence of hemorrhage in producing a somewhat greater reduction in total effective blood flow than effective plasma flow. Mean normals from Smith[5]

Results.—All 11 cases are included in Table III and in Figs. 2 through 5; these figures are constructed from average values listed in Table III. In the 3 with the lowest values (Cases 133, 138, and 150), in whom tests were repeated, only the initial observations are shown in Figs. 2 through 5. These same initial observations and those noted when the tests were repeated are represented in Figs. 6 through 8.

1. *Filtration Rate and Effective Plasma Flow* (Table III and Fig. 2): The values for the filtration rate and plasma flow were significantly below normal in one patient twenty hours after wounding (Case 139); he was the only one of the 5 studied during the early postoperative period who had severe initial shock. In 2 other patients glomerular filtration rate and plasma flow were in low normal ranges.

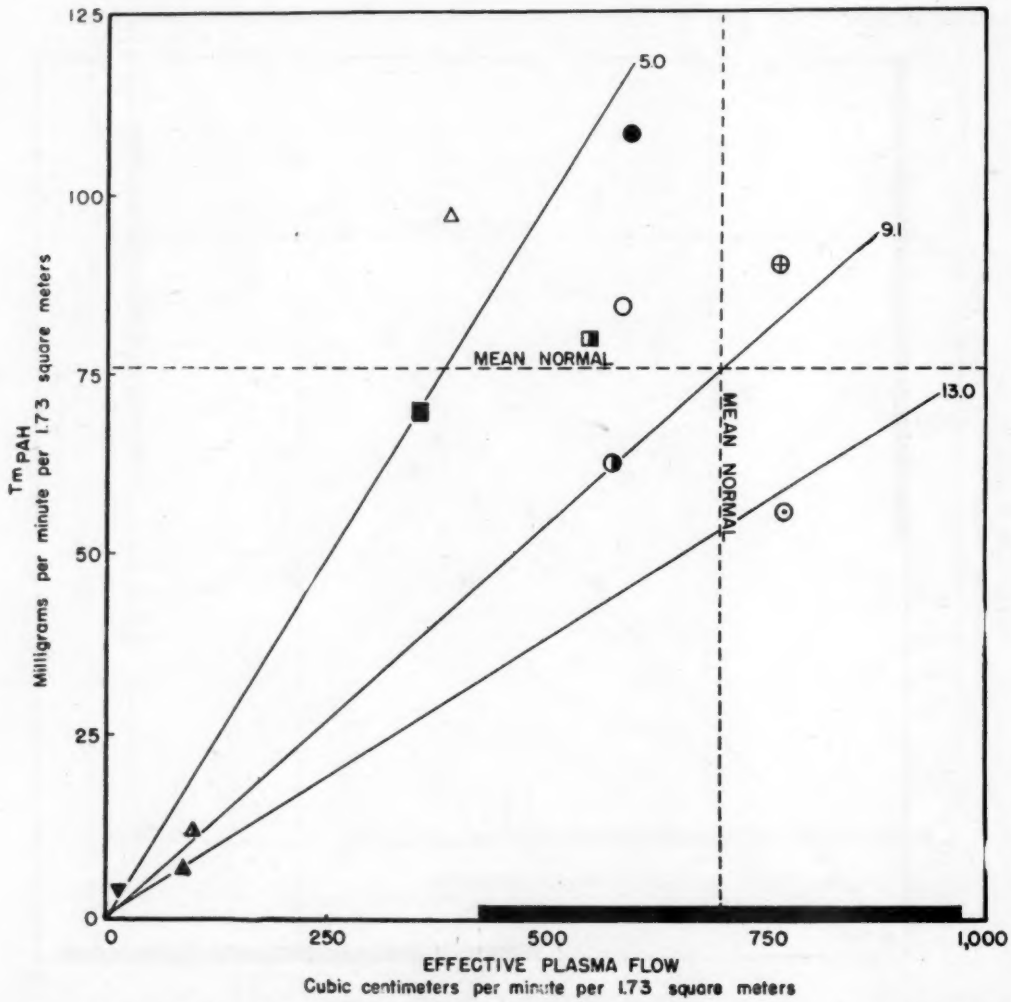

Fig. 4.—Relationship between effective plasam flow and maxinal tubular excretory capacity. Mean normal of plasma flow is the same as in Fig. 2. Normal for T_{mPAH} from Goldring and Chasis (p. 56),[3] for which there was not a sufficiently large series for statistical treatment—hence, no standard deviations are shown. Diagonal lines represent $\frac{C_{PAH}}{T_{mPAH}}$. Variation is wide, but noteworthy perhaps is the fact that all but two cases had ratios less than normal.

Marked diminutions of both components in the 3 patients with severe renal failure are evident (Cases 133, 138, and 150). There are lesser degrees of impairment in the 2 in whom renal failure was only coincident in subsequent death (Cases 143, 147), and in the patient who had fairly well recovered from renal failure (Case 125).

The tendency of glomerular filtration rate and effective plasma flow to diminish proportionately are demonstrated in most cases by the relatively normal filtration fractions ($\frac{C_M}{C_{PAH}}$). Each of the three patients with very low filtration rates and plasma flow had moderate hypertension at the time the tests were performed. In none are the high filtration fractions characteristic in essential hypertension present.

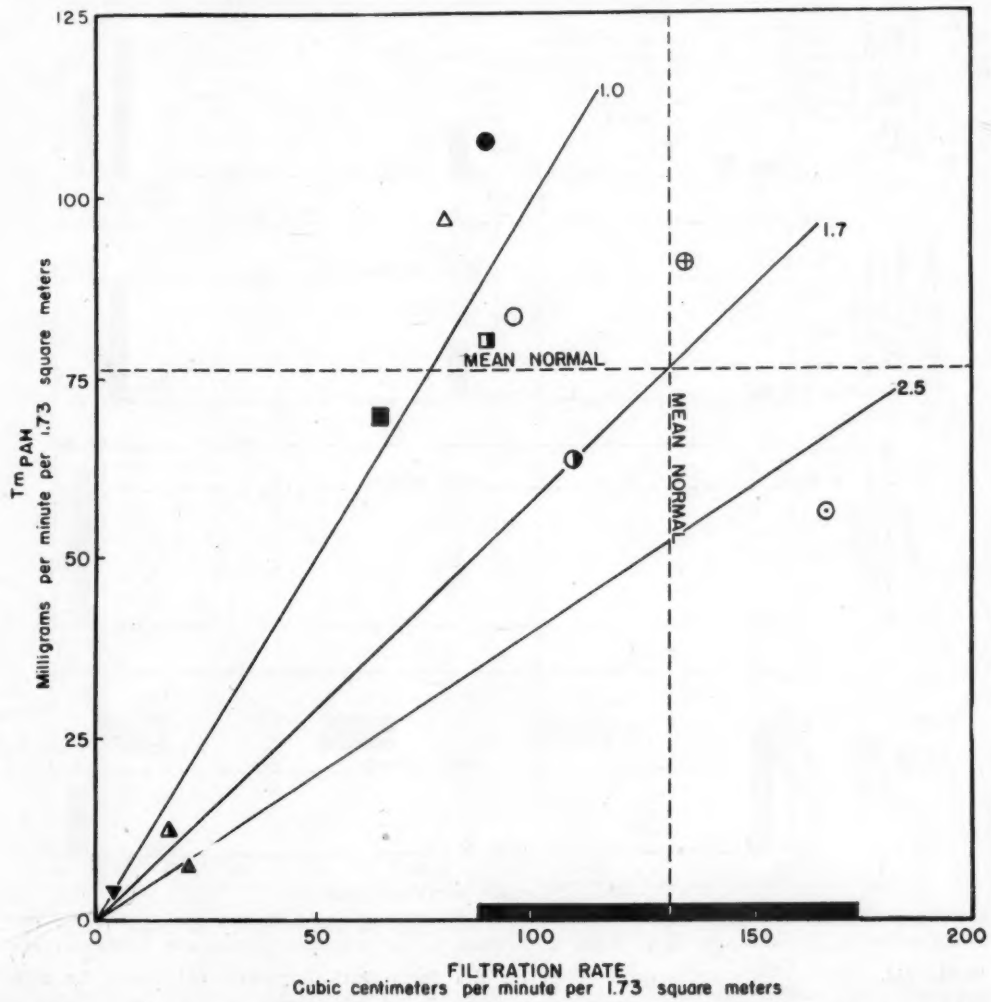

Fig. 5.—Relationship between filtration rate and maximal tubular excretory capacity. Mean normals derived from sources mentioned in Figs. 2 and 4. There is a tendency for ratio of $\frac{C_M}{T_{mPAH}}$ to be above normal.

2. *Effective Renal Blood Flow* (Table III, Fig. 3): Here the influence of low hematocrit is shown. Total effective blood flow is proportionately reduced more than effective plasma flow, in most cases.

3. *Maximal Tubular Excretory Capacity* (Table III, Fig. 4): Variation is wide in measuring maximal tubular excretory capacity, but it was significantly low only in the 3 patients with marked renal failure. It is of interest that the

one patient with severe initial shock who was studied twenty hours after wounding had low filtration rate and renal blood flow but normal Tm (Case 139). Relating plasma flow to maximal excretory capacity ($\frac{C_{PAH}}{Tm_{PAH}}$), diagonal line in Fig. 4, gives an expression of the virtual quantity of plasma cleared per unit of functionally active tubular tissue. Ratios below normal should in-

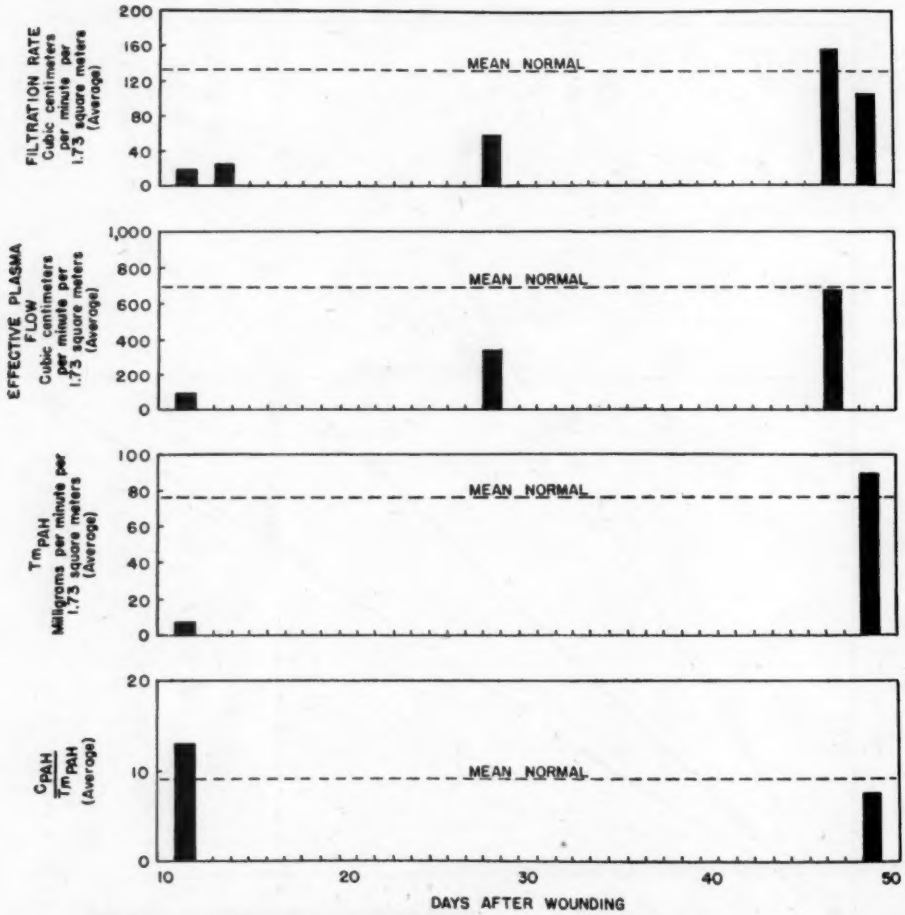

Fig. 6.—Patient with severe renal failure and subsequent recovery diuresis (Case 133). Mean normals are those used in Figs. 2 through 5, and average values are those given in Table III. The $\frac{C_{PAH}}{Tm_{PAH}}$ ratio represented on the forty-ninth day was calculated by using C_{PAH} measured two days previously. Not (1) relatively proportionate reduction in glomerular filtration rate, effective plasma flow, and maximal tubular excretory capacity; and (2) similar recovery rates for all three components.

dicate relative renal ischemia. It may be significant that this ratio was normal or below normal in 9 cases, and that it was lowest in the patient tested shortly after he had recovered from severe shock (Case 139).

Relating filtration rate to maximal tubular excretory capacity ($\frac{C_M}{Tm_{PAH}}$), diagonal line in Fig. 5, gives an expression of glomerular function per unit of

functioning tubular tissue. Ratios below normal should indicate greater relative impairment of glomerular function than tubular, and high ratios the reverse. Nine of the 11 have either a normal or a low ratio, a fact difficult to explain in view of the anatomic lesion in this type of case.

4. *Rate of Recovery* (Table III, Figs. 6, 7, and 8): Three patients who had severe renal failure but recovered are represented. Initial observations were made during periods of maximum failure, subsequent ones after recovery had largely taken place. In general, on the basis of clearance measurements,

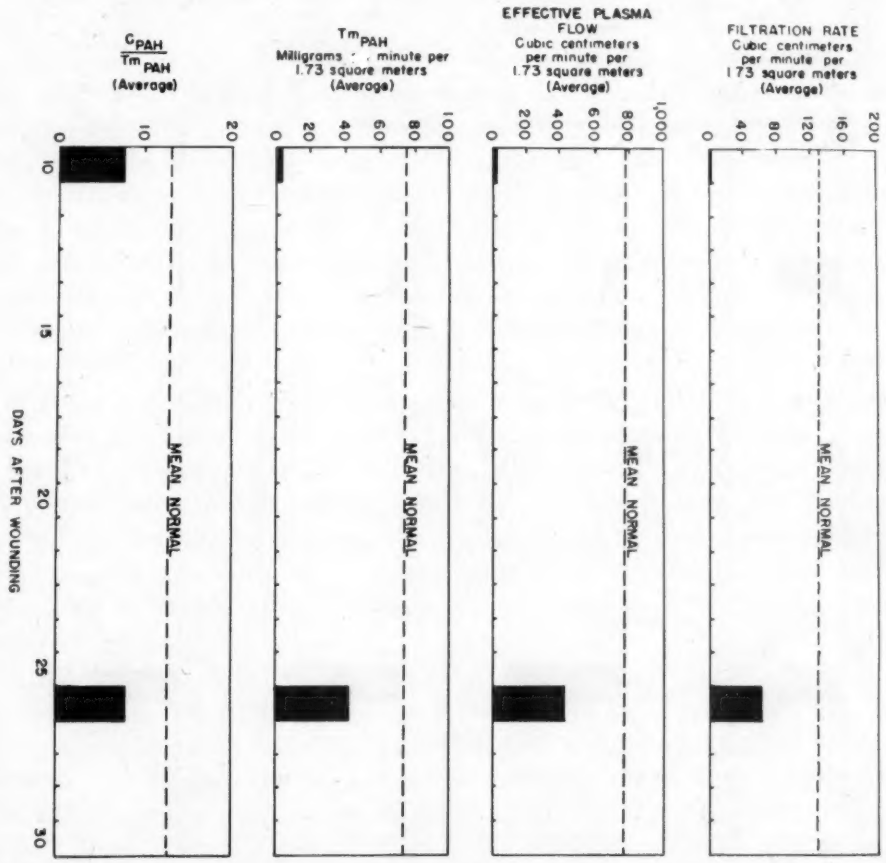

Fig. 7.—Patient with severe renal failure and subsequent recovery diuresis (Case 150). Sources are the same as mentioned in Fig. 6.

all portions of the nephron were about equally affected; recovery likewise occurred at about an even rate in all portions. Restitution of function was apparently complete forty-nine days after wounding in 1 patient (Fig. 6), partially so in the other 2 patients twenty-six days after wounding (Figs. 7 and 8).

URINE CONCENTRATION TESTS

Although the value of the urine concentration test was self-evident, practical difficulties prevented our using it as a measure of renal function in many cases. Fluid restriction during the first few postoperative days was almost

always inadvisable for the patients' welfare. Pituitrin was therefore employed, using the accepted method of administering 0.5 c.c. of posterior pituitary extract (10 units) subcutaneously and collecting urine specimens one and two hours afterward. Many of the patients in whom we should like to have known concentrating ability were receiving considerable amounts of sodium chloride intravenously daily. Since the antidiuretic hormone is less effective after salt-induced diuresis, the number of patients in whom the pituitrin test would have

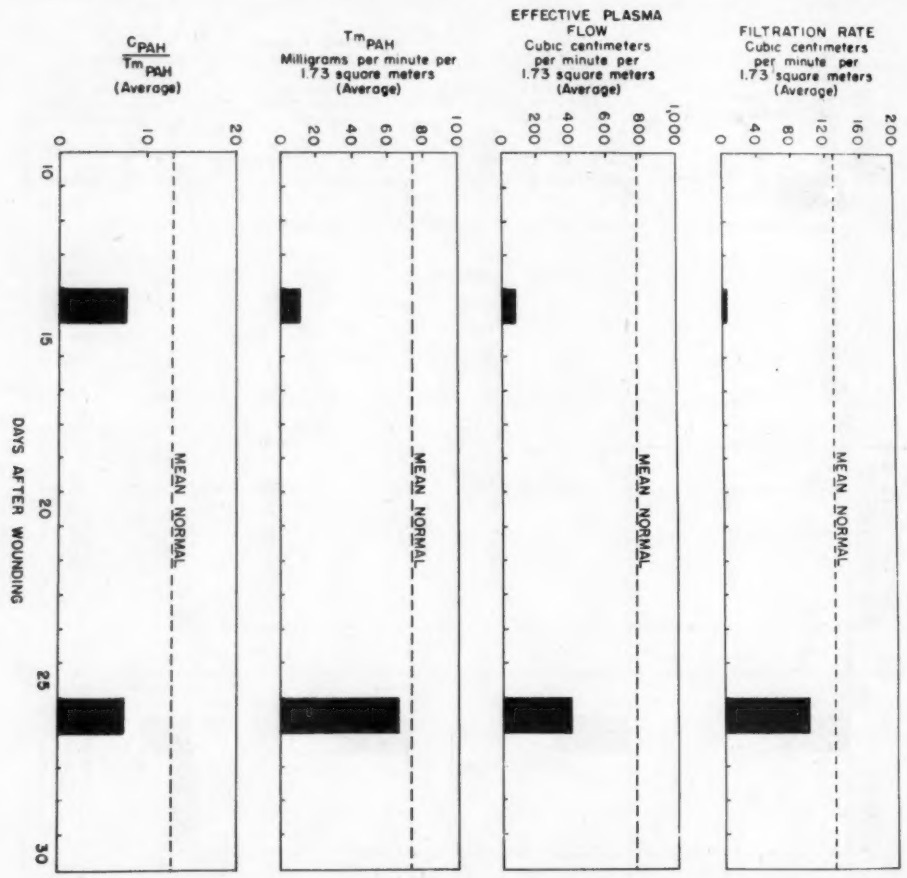
$\frac{C_{PAH}}{Tm_{PAH}}$ (Average)
Tm_{PAH} Milligrams per minute per 1.73 square meters (Average)
EFFECTIVE PLASMA FLOW Cubic centimeters per minute per 1.73 square meters (Average)
FILTRATION RATE Cubic centimeters per minute per 1.73 square meters (Average)
0 10 20
0 20 40 60 80 100
0 200 400 600 800 1,000
0 40 80 120 160 200
10 15 20 25 30
DAYS AFTER WOUNDING
MEAN NORMAL
MEAN NORMAL
MEAN NORMAL
MEAN NORMAL

Fig. 8.—Patient with severe renal failure and subsequent recovery diuresis (Case 138). Sources are the same as mentioned in Fig. 6.

been complicated by recent administration of normal saline solution was large; but in most instances we did not feel justified in requesting that the saline solution be withheld. A compromise regimen was established in which all parenteral fluids were withheld for a period of seven to eight hours before the pituitrin was administered, where such restriction would clearly not be harmful in any way to the patient.

Data on the 32 patients in whom concentrating ability of the kidneys was tested in this manner during the postoperative days indicated are shown in Table IV.

TABLE IV

SPECIFIC GRAVITY OF URINE	DAYS FROM WOUNDING TO FIRST TEST	DEGREE OF INITIAL SHOCK (NO. OF CASES)				INITIAL HYPOTENSION (NO. OF CASES)	OLIGURIA OR ANURIA (NO. OF CASES)	"HIGH AZOTEMIA" (NO. OF CASES)	TOTAL NUMBER CASES
		NONE	SLIGHT	MODERATE	SEVERE				
Over 1.025	2 to 7	3	6	5	3	8	6	2	17
1.018 to 1.024	2 to 8	0	1	8	0	5	5	1	9
Under 1.018	1 to 17	1	1	1	3	4	5*	5	6

*Actual output unknown in two cases, but good presumptive evidence of oliguria present.

Of the 17 patients in whom there was no impairment of concentrating ability during the first week after wounding, 8 had initial moderate or severe shock and initial hypotension. Two of these 17 subsequently had "high azotemia." Of the 9 patients with slightly decreased ability to reabsorb water from the kidney tubules (specific gravity 1.018 to 1.024), 8 had moderate initial shock; 5, initial hypotension;5, oliguria or anuria; and one, "high azotemia." In the group of 6 cases with marked impairment of concentrating ability, 4 had moderate or severe shock, and 4 had hypotension. Five of these 6 had marked and prolonged azotemia, and have been discussed previously in this paper and elsewhere.[1, 2]

The test was done more than once in 8 patients. Of 2 in whom concentration was 1.018 at the time of the first test, each concentrated to 1.020 two and seven days later, respectively. One whose specific gravity at first was 1.017 concentrated to 1.022 three days later. Of the 3 cases just mentioned, one also had "high azotemia" and oliguria, and 2 had normal urine output and nonprotein nitrogen under 65 mg. per cent. The remaining 5 had recovery diuresis, and after periods of fourteen to forty days were still unable to make a concentrated urine.

Although this series is very small, there is a suggestion that the concentrating function of the kidneys follows somewhat the same pattern as the ability to excrete phenolsulfonphthalein, mannitol, and sodium para-amino hippurate. Ability to concentrate urine may diminish following shock, and improve over a period of three to seven days, unless renal failure is severe (recovery diuresis), in which case maximal tubular reabsorption of water remains diminished for many days or weeks. In two cases specific gravity was fixed even after clearance of mannitol and sodium para-amino hippurate had returned to normal (Cases 125 and 133[1]).

DISCUSSION

It has been demonstrated by Lauson, Bradley, and Cournand[4] that during the state of shock, glomerular filtration rate and effective plasma flow are reduced. These workers have further advanced evidence that reduction in renal blood flow is mediated by active vasoconstriction of the renal blood vessels, as well as by reduction of arterial pressure.

None of our studies were carried out during the state of shock. Those performed in the first few days after trauma suggest that the reduction in

kidney function may persist for some days after shock is relieved, even though the usually accepted signs of renal failure (suppression of urine output, nitrogen retention) may be meager. These patients probably rapidly regain normal kidney function.

If the initial insult, whatever it is, is greater, the resulting renal insufficiency is much more severe and prolonged, and in a significant proportion of instances results in death in uremia. A few patients do recover, however, with gradually increasing function over a period of days to weeks as indicated by rate of recovery of ability to excrete phenolsulfonphthalein, by improved glomerular filtration, by increased effective plasma flow, maximal tubular excretory capacity, and concentrating capacity of the urine.

Although the histologic picture in fatal cases might suggest a selective functional impairment of the lower nephron,[1] our studies indicate that all functional components of the kidneys are about equally impaired. Glomerular filtration rate and effective plasma flow were reduced in essentially proportionate degrees in most of the patients we studied. That there may have been some relative ischemia in these cases is suggested by the fact that in the few cases where clearances were done the ratio of $\frac{C_{PAH}}{Tm_{PAH}}$ showed a tendency to be low. One bit of evidence in favor of greater relative insult in the lower nephron should be cited from the two cases in which ability to concentrate urine was still much impaired after clearances had returned to normal. Mannitol serves as a measure of glomerular filtration; sodium para-amino hippurate is believed to be excreted in the proximal tubules. Urine concentration takes place further down the nephron in the loop of Henle. Is this lag in recovery of concentrating capacity a manifestation of greater relative damage to the lower nephron?

SUMMARY

1. The results of measurements of phenolsulfonphthalein excretory capacity, glomerular filtration rate, effective renal blood flow, maximal tubular excretory capacity, and urine concentration tests following wounding and subsequent resuscitation if shock was present have been presented.

2. Phenolsulfonphthalein excretory capacity determined within seventy-two hours after wounding, and after resuscitation had been effected and surgery completed, was significantly diminished in patients with initial shock, and was normal in those without initial shock. Where this measurement was repeated, excretory capacity rapidly returned toward normal during the first two weeks after wounding in those patients with evidence of minimal renal failure, and more slowly in those with signs of more severe kidney damage.

3. One of 5 patients showed significantly low glomerular filtration rate and effective plasma flow but normal maximal tubular excretory capacity thirty hours after wounding and severe initial shock. Measurements of the same functions were normal in the other 4 patients studied in the early period after wounding, none of whom had appreciable shock.

4. Six patients who had a nonprotein nitrogen of 65 mg. per cent or higher after wounding were studied during various phases of their renal in-

sufficiency. The results suggest that all portions of the nephron suffer functional impairment.

5. Ability to produce a concentrated urine may diminish following shock and rapidly improve over a period of three to seven days, unless renal failure is severe, in which case maximal tubular reabsorption of water is impaired for many days. In two cases urine specific gravity remained fixed and low even after glomerular filtration rate, effective renal plasma flow, and maximal tubular excretory capacity had returned to normal.

REFERENCES

1. Mallory, T. B., Simeone, F. A., Beecher, H. K., Sullivan, E. R., Burnett, C. H., Shapiro, S. L., and Smith, L. D.: The Physiological Effects of Wounds, The Board for the Study of the Severely Wounded, Washington, D. C., 1948, Government Printing Office. (In Press.)
2. Burnett, C. H., Shapiro, S. L., Simeone, F. A., Beecher, H. K., Mallory, T. B., and Sullivan, E. R.: Post-traumatic Renal Insufficiency, SURGERY **22**: 1947.
3. Goldring, W., and Chasis, H.: Hypertension and Hypertensive Disease, New York, 1944, Commonwealth Fund.
4. Lauson, H. D., Bradley, S. E., and Cournand, A., with the technical assistance of Andrews, V. V.: The Renal Circulation in Shock, J. Clin. Investigation **23**: 381-402, 1944.
5. Smith, H. W.: The William Henry Welch Lectures, J. Mt. Sinai Hosp. **10**: 59, 1943.
6. Stitt, E. R., Clough, P. W., and Clough, M. C.: Practical Bacteriology, Haematology, and Animal Parasitology, ed. 9, Philadelphia, 1938, The Blakiston Company, p. 733.

Review of Recent Meetings

THE FIFTEENTH ANNUAL SESSION OF THE SOUTHEASTERN SURGICAL CONGRESS POSTGRADUATE ASSEMBLY

LOUISVILLE, KY., MARCH 10 TO 12, 1947

MARSHALL L. MICHEL, JR., M.D., NEW ORLEANS, LA.

The fifteenth annual session of the Southeastern Surgical Congress Postgraduate Assembly was held at the Brown Hotel, Louisville, Ky., on March 10, 11, and 12, 1947.

E. L. Henderson presided and **B. T. Beasley** served as secretary. **J. B. Lukins** was general chairman of the committees on arrangements.

R. S. Dinsmore, Cleveland: **Surgical Aspects of Thrombocytopenic Purpura.**—Other platelet depressing conditions must be ruled out. The bone marrow is usually normal in thrombocytopenic purpura. Any slight abnormality is merely a reflection of blood loss. The megacaryocytes fail to demonstrate qualitative or quantitative alteration.

If the spleen is enlarged, one is probably not dealing with essential thrombocytopenic purpura. The typical microscopic picture shows a slight generalized hyperplasia of the pulp and lymphoid tissue with little or no fibrosis and no unusual pigmentation or abnormal cells.

The anesthesia of choice for splenectomy is nitrous oxide and ether. Dinsmore recommended a left oblique subcostal incision. The spleen is delivered medially and forward and a pack placed in the posterior fossa. The gastro splenic omentum is divided and the vasa brevia are ligated. The lienorenal ligament can then be plainly visualized and ligated. If adhesions to the colon are present, these should be clamped and ligated.

The vessels of the splenic pedicle are dissected and ligated separately. En masse ligation is permissible but not desirable. The spleen can then be removed in toto. The splenic pedicle should be again carefully inspected. The abdomen is closed in layers with interrupted sutures of cotton.

Dinsmore reported a series of twenty-eight cases of splenectomy for thrombocytopenic purpura. The average age was 26 years and 8 months. There were three deaths, a mortality of 10.7 per cent. Twenty-two patients (78.6 per cent) were cured or markedly improved. Of six patients in whom splenectomy was advised but not performed, four died.

Postoperative evaluation of the patient depends entirely on whether or not bleeding stops and how the patient feels. It is no longer believed that a marked platelet response indicates a good prognosis. In many cases, in which good results were obtained, the platelets increased only slightly.

The most common cause of death is cerebral hemorrhage. Intractable headache is often a premonitory symptom of this serious complication.

William P. Nicolson, Jr., Atlanta: **Carcinoma of the Breast—Its Prevention and Treatment.**—There are four conditions which contribute to the development of cancer of the breast; (a) improper or no support; (b) lactation; (c) mastitis; (d) stagnation.

The importance of a properly fitting brassiere in correct support of the breast was emphasized. Mastitis is often a premalignant condition. The use of the breast pump to prevent intraductal stagnation is an important phase in the proper care of the female breast.

The treatment of cancer of the breast is determined by four factors: (1) extent of the disease; (2) nature of the tumor; (3) age of the patient; (4) physical condition of the patient. The treatment should be individualized to fit each particular case. As a rule, however, it should be radical and should combine surgery with pre- and postoperative irradiation.

The amount of skin removed should be extensive. Three fingerbreadths from the edge of the tumor on all sides should be a minimum.

In women in the premenopausal period, it is important to give additional irradiation to the ovaries. Radical mammectomy should not be performed if one of the following is present: (1) distant metastases; (2) secondary or daughter growths in the skin; (3) fixation of the growth to the chest wall; (4) fixation of the nodes in the axilla; (5) swelling and edema of the arms.

Simple mastectomy, combined with pre- and postoperative irradiation, is sufficient in the older age group. Extreme radicalness should be reserved for the younger patient.

Warren H. Cole, LeRoy Walter, and John Reynolds, Chicago: **Surgical Treatment of Peptic Ulcer.**—Thirty cases were analyzed in which vagotomy was performed for peptic ulcer with no operative mortality. In all cases, there was a marked diminution in gastric acidity and relief of pain. The following are the indications for vagotomy: (1) intractable symptoms; (2) pyloric obstruction unrelieved by medical measures (gastroenterostomy or gastrectomy should be done along with the vagotomy); (3) gastrojejunal ulceration; (4) gastric ulcers in which a high acidity is present and in which there is no suggestion of malignancy.

The insulin test will determine the degree of completeness of the vagus nerve section. The complications of vagotomy are not severe. Gastric retention can be eliminated by adequate postoperative decompression. The Abbott-Rawson tube was used postoperatively in this series. Cole and his associates prefer the abdominal approach for vagotomy, in order to inspect the ulcer and perform gastroenterostomy if necessary.

Virgil S. Counseller, Rochester, Minn.: **The Etiology and Treatment of Vesicovaginal Fistula.**—Vesciovaginal fistulas are of three types: (1) postoperative, (2) postirradiation or radium therapy; (3) postpartal.

The most common type is the postoperative fistula. The operative procedures most often followed by fistulas are total abdominal hysterectomy, vaginal hysterectomy, and vaginal plastic. Total hysterectomy is not as widely indicated as some are inclined to recommend.

The bladder is injured in one of two ways: (1) It may be actually cut; (2) a suture may be passed through the wall of the bladder into the lumen. When the latter of these two accidents occurs, the fistula does not appear for seven to ten days.

Counseller advised strongly against the use of right angle clamps on the upper part of the vagina, because of the danger of including parts of the bladder in the clamp. The risk of infection is slight when the vagina is opened. Direct vision with good hemostasis enables the operator to be certain of not harming the bladder.

Adequate urologic examination is important. The position and type of fistula can be determined. If the ureter is involved and there is kidney infection, nephrectomy is indicated. If the ureter is involved and there is no evidence of kidney infection, it may be possible to reimplant the ureter.

In the treatment of a postirradiation fistula, surgical repair should be postponed for at least three years. It is often necessary in such cases to transplant the ureter to the colon.

A motion picture was shown demonstrating the operative technique for the repair of a vesicovaginal fistula. Vaginal examination should not be performed for at least twenty-one days following operation.

Leonard W. Edwards, Nashville: **Results in Biliary Tract Surgery.**—Two hundred cases, in which biliary surgery was performed, were analyzed. There were 199 cholecystectomies and one cholecystostomy. Twenty-eight of these cases were acute cholecystitis and of these, 27 had stones. Ninety per cent of all the patients showed the presence of stones. The end results are not good in cases in which there is only questionable pathology in the biliary tract.

The vascular changes in cholecystitis are important, especially in the aged. Bacterial infection plays a secondary role. Therefore, cholecystectomy is indicated early in the disease, before infection occurs.

There were thirteen perforations, nine of which occurred in the gall bladders with acute conditions, representing 32 per cent of the acute cases. The signs of impending perforation are increased pain, increased rigidity, severe nausea and vomiting, high fever, and an increase in the white blood count. If the indications are present, the common bile duct should be explored even though the gall bladder is acutely inflamed.

Choledochostomy was performed in 9 per cent of the cases. In 83 per cent, stones were found in the common bile duct.

Edwards prefers a transverse incision for biliary operations. Anomalies of the ducts and vessels were discussed, and lantern slides were shown illustrating the anomalies encountered in this series.

Claude S. Beck, Cleveland: **Pressures on the Heart.**—Heart action can be disturbed by: (1) pressure, (2) angulation, (3) rotation.

Rotation and angulation are poorly tolerated by the human heart. Dislocations of the heart, causing rotation and angulation, are sometimes the result of inflammatory disease of the mediastinum, therapeutic pneumothorax, or malformations of the chest wall. Operative intervention can correct such displacements.

Pressure on the heart can be classified as ''acute'' and ''chronic.'' Beck prefers the term ''acute pressure'' to the generally used term of ''tamponade.''

The most common cause of acute pressure is stab wound of the heart. Spontaneous and traumatic ruptures of the auricles may occur following crushing chest injuries. Not all of these patients die suddenly. Some could be saved by operation.

Chronic cardiac pressure can be either generalized or localized. Three cases were reported with compression scars over the right auricle and ventricle. Operative relief of these localized compressions was successful.

In another case, there was a ring of calcium deposited around the pulmonary artery, which was removed surgically.

A case was reported in which the patient had a severe contusive injury of the chest. Later, he developed signs of compression of the heart and died. Autopsy revealed that the parietal pericardium had an opening in it. Both ventricles herniated through this opening and cardiac compression resulted. Cure could have been obtained by replacing the heart in the pericardium and closing the opening in the pericardium.

A common cause of compression is generalized pericardial scarring. Beck has operated on fifty-seven such patients; 68.4 per cent of these are living and cured and two (5.3 per cent) are improved. There were ten postoperative deaths—five from tuberculosis and five from other causes. There was only one operative death, and this was due to ventricular fibrillation.

A case was reported in which there was a tumor mass in the wall of the left ventricle. The mass was the size of a tangerine. It had a calcified wall and the content was solidly packed debris without cellular morphology. The mass was successfully removed, and the patient is living without symptoms.

Pericardial effusion may cause compression of the heart. If the fluid cannot be aspirated, surgical internal drainage should be established into the left pleural cavity.

Norman F. Miller, Ann Arbor: **The Abuse of Pelvic Surgery in the Female.**—The divergent views held by physicians regarding the need for certain types of pelvic surgery, plus the story told by the removal of countless organs now recognized as normal, would indicate that some attention to this subject is in order.

It is important that the profession be aware of the following facts:

(1) The decreasing confidence manifested by patients in physicians when operation is advised. This may be a manifestation of the American custom of ''shopping,'' but some of it represents a true change in patient-physician relationship.

(2) In recent years, there has been a marked increase in the incidence of pelvic surgery, as shown at daily hospital listings, in spite of new forms of chemotherapy, reduced birth trauma due to improved obstetrics, and a vastly increased knowledge concerning the functional changes in the female generative organs.

(3) During the war years, when civilian hospitals were filled to capacity, operating schedules rose to a new high and showed an increasing number of pelvic operations. Of course, some of this increase can be attributed to insurance programs and to higher wages, but these factors do not explain all of the wartime increase.

(4) We are now in the midst of the greatest educational program for the development of surgical residencies in the history of medicine. We must not fail to recognize that the resulting abundance of surgical talent must also seek an outlet for its skill. In the careful screening of patients for conditions susceptible to surgical treatment, it is imperative that there be available reasonable agreement as to what constitutes surgical disease.

In 1936, **Carpenter** analyzed 1,137 gynecologic specimens from 11 general hospitals. In these specimens there were 314 excised ovaries. Pathologic examination of these specimens of ovaries revealed that 78.9 per cent of the ovaries were within normal physiologic limits. The changes which were present were as follows: follicle cyst, 57 per cent; simple cyst, 11.1 per cent; corpus luteum, 10.8 per cent.

It is important to recognize the fact that the normal functioning ovary varies in size. This alteration seldom exceeds 5 cm. Persistent enlargement beyond the normal 5 cm. limit calls for removal.

In a study of 934 enlarged ovaries, at the University of Michigan, in 1942, Miller noted that 49.3 per cent of the ovaries removed were under the 5 cm. limit of normal. Further analysis of the 461 small ovarian tumors under 5 cm. revealed that 96.9 per cent of these were of the simple type and removal was not justified.

In 1937, **Cook** reported 1,378 cases of ovarian cysts of less than 7.5 cm. He observed that the vast majority of these were retention cysts and were of no clinical significance.

Mengert has reported a study of 1,320 ovaries removed at one hospital. Of these, 993 (75 per cent) were normal or contained follicular or corpus luteum cysts.

Miller is of the opinion, on the basis of his own experience and that of others, that there is little reason for oophorectomy on the basis of minor palpable cystic change. This does not apply to ovaries showing progressive increase in size beyond 7.5 cm. nor to solid tumors of the ovary. Although oophorectomy is a simple surgical procedure, no surgeon is properly equipped to perform this operation until he has thoroughly familiarized himself with the normal physiologic variations of the ovary.

The uterus also suffers from unjustified surgical annihilation. Here again, failure to comprehend the full physiologic function of the organ is a factor. It is important to remember that the uterus serves both as a user and as a stimulator of ovarian hormones at a time in life when the sap of youth is running low. Premature removal of the normal uterus hastens atrophy and functional inactivity of the ovaries. Excision of the uterus in the absence of disease cannot be justified any more than can removal of the normal breast.

In a study of 246 hysterectomies at ten different hospitals in ten different communities in three middle western states, Miller discovered a none too happy picture. Approximately one-half of these (43.9 per cent) were performed in patients between the ages of 40 to 49 years.

Sixty-six per cent were subtotal, 29 per cent total, and 5 per cent vaginal hysterectomies. In view of the enthusiasm and propaganda favoring the total operation, one might have expected a higher incidence of complete extirpation. It is Miller's opinion that the total operation is more difficult than the subtotal, other opinions to the contrary notwithstanding. Furthermore, except for the obvious fact that future disease of the cervix is eliminated, the other advantages sometimes claimed for complete hysterectomy still remain to be proved. He is unimpressed by the evidence presuming to prove a lower mortality and morbidity for the total operation. Total hysterectomy should certainly not be attempted by the occasional operator.

The leading symptom in this series of cases was excessive menstrual bleeding; 41.4 per cent of these patients presented this primary symptom. It is interesting to note that 17.4 per cent had no symptoms whatsoever.

The findings at pelvic examination prior to operation are of interest: 18.6 per cent had a perfectly normal pelvis at examination; in 31.7 per cent it was thought that uterine fibroids were present.

In the final studies of the specimens removed, the pathologist reported that 30.8 per cent of the organs excised revealed no microscopic evidence of disease. The figure is especially revealing since it included, as acceptable findings, diseases of the adnexa, prolapse, hyperplasia of the endometrium, and pelvic relaxation. The fact that 17.4 per cent of the patients presented no symptoms and 18.6 per cent had no palpable pelvic disease does not of itself warrant the assumption that almost one-fifth of the patients in this particular series had acute "remunerative" or "hip pocket" hysterectomies. However, the discovery that 30.8 per cent were found to have no pathologic changes in the organs removed is not readily accounted for. Further correlation shows that 41, or 16.6 per cent, had neither symptoms, palpable pelvic disease, nor histopathology of the removed organs.

In 49.7 per cent of the patients the clinical diagnosis was confirmed. In 17.4 per cent the clinical diagnosis was not corroborated but the operation nevertheless considered justifiable. In 33.1 per cent there was either no disease or else disease contraindicating hysterectomy.

Even with the very liberal allowances permitted in this study, Miller found that almost one-third of the extirpated uteri were absolutely free from evidence of disease. If this trend is borne out by further study, it is time that the profession scrutinize the more commonly accepted indications for pelvic operation, especially oophorectomy or hysterectomy.

Thomas Leslie Lee, Ann Arbor, and **H. Fleming Fuller**, Kinston, N. C.: **The Surgical Treatment of Intractable Dysmenorrhea.**—There are two types of dysmenorrhea: (1) primary (functional) and (2) secondary (pathologic).

Presacral sympathectomy is recommended only in the first type. Fifteen cases were reported in which presacral sympathectomy had been performed. The results were uniformly good.

K. M. Brinkhous, Chapel Hill: **Thrombin and Its Clinical Applications.**—The mechanism of hemostasis was reviewed in detail. The time required for the various reactions in the process of hemostasis is of great importance. All thromboplastins are poor hemostatic agents, because too much time is consumed in the formation of thrombin. This fact led to the idea of using preformed thrombin in hemostasis.

Brinkhous was a member of the research group at Iowa which did pioneer work in the purification of thrombin. He briefly reviewed the preparation of purified thrombin. **Seegers** has recently improved this method, and obtained an extremely potent and practically pure thrombin. Bovine thrombin, which was used in these preparations, has shown no antigenicity in man.

Thrombin solution directly applied to a bleeding surface is not efficient. It is necessary to spray the solution under high pressure from a needle and syringe.

The application of thrombin solution by cotton sponges saturated with thrombin will control bleeding promptly, but on removal of the cotton, the clot is broken and bleeding starts again.

To obviate these difficulties, soluble preparations have been introduced as a vehicle for thrombin. The best of these are fibrin foam and gelatin sponges. A third preparation, oxydized cellulose, is acid in reaction and will destroy some of the thrombin.

Local application of thrombin has been used widely in neurosurgery, particularly in controlling dural bleeding, bleeding in tumor beds and along venous sinuses. It also has proved valuable in bone and liver operations, in operative procedures on the nose and tonsils, and in controlling bleeding in the prostatic bed. Thrombin is now used in the control of hemorrhage from donor areas during skin grafting and to hold skin grafts in place.

Gordon S. Fahrni, Winnipeg: **A Few Factors in Thyroid Surgery Influencing Morbidity and Mortality.**—A series of 4,954 cases, in which subtotal thyroidectomy was performed, was analyzed. Of these, 2,430 were of the toxic diffuse type and 2,524 were nodular goiters (including the nontoxic, toxic, and malignant goiters and chronic thyroiditis).

In toxic diffuse goiter, a radical removal of both thyroid lobes was carried out. In nodular goiter, a less radical resection was performed.

Lugol's solution was used preoperatively in all cases, whether obviously toxic or not. Since October, 1945, thiouracil has been used in the severe toxic cases. This drug is discontinued nine to ten days before operation and the patient carried on Lugol's solution until operation. Toxic patients are advised to take 3 to 5 minims of Lugol's solution twice weekly for several months following operation.

Forty-six patients have been operated upon for carcinoma, which is 0.9 per cent of the entire series and 1.8 per cent of the nodular goiters. Radical removal of the gland plus postoperative radiation is indicated in all such cases.

It is important that all patients with nodular goiters, in which the patient has noticed an enlargement or increased firmness of the old goiter, be advised to have thyroidectomy because of the danger of malignancy.

Forty-four patients were operated upon during pregnancy. There were no miscarriages and all patients were carried through their pregnancies satisfactorily. Fahrni advises thyroidectomy during pregnancy as soon as the diagnosis is made, unless the disease should occur during the last trimester and be of relatively low-grade toxicity.

The presence of heart disease with thyrotoxicosis is no contraindication to thyroidectomy. Such patients are greatly improved after thyroidectomy.

In toxic cases, it is important that the patient be gaining weight at the time of operation. Lugol's solution and thiouracil should be used judiciously. Unfortunately, many patients are given Lugol's solution for many months before being sent to a surgeon. Such patients are always very poor risks.

In the preparation of toxic cases for thyroidectomy, the patient should be allowed to be ambulatory.

The over-all mortality was 0.7 per cent. In the toxic diffuse cases, the mortality was 1.1 per cent and in nodular goiters, the mortality was 0.3 per cent. The common causes of death were thyroid crisis, heart failure, pneumonia, and cerebral thrombosis. Other causes of death were hepatic failure, anesthesia, surgical shock, and pulmonary embolus.

In the last 425 thyroidectomies, no deaths have occurred. In these cases, thiouracil has been used in the more toxic cases.

R. B. Mc Knight, Charlotte: **An Analysis of 1,100 Consecutive Thyroidectomies.**—In this series, there were five deaths, two in white and three in colored patients, an overall mortality of 0.45 per cent. This revealed a mortality rate of 0.2 per cent in white patients and 4.0 per cent in colored. There were no deaths in the severely toxic cases. He attributes this largely to the preoperative use of intravenous iodine in doses of 100 to 150 minims of Organidin in 1,000 c.c. of 10 per cent glucose given daily three to five days before operation. In the entire series there were no crises. Neither thiouracil nor any of the allied drugs was used in this series. The prevention, incidence, and management of such immediate complications as bilateral recurrent nerve injury, hemorrhage, parathyroid disturbance, psychoses, etc., were discussed.

Irvin Abell and **Irvin Abell, Jr.**, Louisville: **Endometriosis: An Analysis of Personal Experience.**—Endometriosis may be divided into five groups **(Sampson)**: (1) direct or primary endometriosis; (2) peritoneal or implantation endometriosis; (3) transplantation endometriosis; (4) metastatic endometriosis; (5) developmentally misplaced endometrial tissue. The history of endometriosis was reviewed in detail.

Abell and Abell, Jr., reported a case in which a catheter remained in the uterine cavity for four years without causing unusual symptoms. Perforation of the uterine wall then

occurred, and the catheter worked its way into the left ischiorectal fossa. Eventually a sinus tract developed to the outside. Operative exploration revealed that endometrial implantation followed the course of the catheter. These implants were found in the entire fistulous tract from the uterus to the opening in the skin over the ischiorectal fossa. The patient was cured by radical excision of the fistulous tract and removal of the catheter.

The choice of treatment is between deferred treatment, conservative surgery, and either surgical or radiation castration. The young woman who has been assured that no serious consequences will result from deferred operation, may, in the hope that the pelvic condition will subside or that she will become pregnant, prefer to suffer mild discomfort rather than accept the risk of surgical castration.

The young woman in whom operation is unavoidable, either in the longing for a child or the fear of premature menopause, may earnestly desire conservative surgery with its associated risk of a second laparotomy.

An older woman who can anticipate an early menopause may endure the disability with the expectation of its early termination. Upon the evaluation of such factors rests the policy of conservatism.

A series of 170 cases of endometriosis was reported. Only one patient under the age of 20 years was operated upon. The highest instance was during the third decade. There were only fifty-one single women in the series, indicating that sterility is in some instances of no assistance in diagnosis. Of the 119 married women, 54, or 50 per cent, were childless, and of these 54, some 28 stated that they were unable to become pregnant.

There were 24 instances of acquired dysmenorrhea, 9 of menorrhagia, and 5 of metrorrhagia. Thirty-three patients were completely symptomless, 14 of whom came in for physical examination and 19 because of enlargement of the abdomen.

The classical symptoms of acquired dysmenorrhea occurred only 24 times, of primary sterility but 28 times, and of characteristic pelvic pain in only 31 cases. In only 77 of the 170 cases did endometriosis occur alone. In 93 cases it was associated with other pelvic disease.

The affinity of this disease for the ovaries accounts, in part, for the surgical castration essential to a complete cure in 66 per cent of the reported cases. Cases seen in the early stages of the disease numbered only 31. In 4 of these, an opportunity presented itself to observe the patient from the time of onset of pelvic pain and tenderness until the mass developed. The lesions were palpable after two, five, six, and twelve months.

Donald T. Imrie, Vicksburg: **Osteomyelitis Today.**—At the present time, there is an improved picture of osteomyelitis as the result of sulfanilamide and penicillin therapy. Indications for surgery are not completely agreed upon. The need for individualizing cases on the basis of ''variable factors'' as well as ''basic common factors'' was emphasized. The effect of penicillin on these factors was discussed, with emphasis on early administration before thrombosis of the vessels has occurred and isolation of the bone from the general circulation. Large doses of penicillin are recommended. As much as 100,000 units of penicillin every three hours may be required, because a certain amount of infarction of bone may already have occurred in spite of negative x-ray findings.

Roentgenograms were shown of a patient with staphylococcus septicemia and acute hematogenous osteomyelitis treated early enough to prevent actual bone necrosis. Another case showed sequestration but arrest of further necrosis. A third case revealed a low-grade infection which required the drainage of a subperiosteal abscess. A fourth case exemplified the type of osteoplastic work done in the old chronic cases. Such radical surgery is made safe with penicillin.

Surgical intervention is rarely necessary in the acute cases, except those in which subperiosteal abscess develops. The abscess should be evacuated and the wound may be closed, if penicillin is given.

Casts or splints should be used only when necessary to facilitate healing of a pathologic fracture.

David R. Murphey, Tampa: **The Use of Atmospheric Pressure in Obliterating Axillary Dead Space Following Radical Mastectomy.**—After performing radical mastectomy, it is impossible to close the wound without trapping air beneath the skin flap. If this entrapped air is removed by aspiration following airtight closure of the skin, the skin flaps are pressed into contact with the underlying tissue by atmospheric pressure and this apposition will be maintained unless the vacuum is broken by an accumulation of fluid.

Before closure of the wound, a large (24 S) catheter containing multiple perforations is passed through a small stab wound, making a snug fit just anterior to the latissimus dorsi muscle, and its tip placed in the apex of the axilla, but not in contact with the vessels and nerves. The skin is then closed. A syringe is attached to the catheter and the air withdrawn from the axilla. The skin flaps are immediately sucked into the axilla. The skin flaps are then arranged so that they fit smoothly into the axillary dead space. The catheter is tied and a dressing applied, leaving the arm free. Thereafter, the catheter is aspirated every twelve hours. Between aspirations, the catheter is tied to prevent the entry of air into the wound with elevation of the flaps. Continuous suction of the Wangensteen type was first used, but was abandoned due to a tendency for tissue to enter the perforations and obstruct the catheter when suction was maintained.

This method has been used successfully in twenty-five cases, and Murphey is of the opinion that it adequately obliterates all dead space, with minimal fibrosis.

T. C. Davison and **A. H. Letton**, Atlanta: **Muscular Relaxation in Abdominal Surgery With the Use of Pentothal-Oxygen and Curare—Report of Over 1,000 Cases.**—A series of 1,000 abdominal cases, in which pentothal-oxygen and curare anesthesia were used, was analyzed.

This is an efficient type of anesthesia for abdominal surgery and has certain advantages over spinal and inhalation anesthesia. There was no mortality in this series which could be directly attributed to the anesthesia.

William Milton Adams, Memphis: **Free Grafting of the Nipples in Mammoplasty.**—Adams presented an excellent motion picture demonstrating a technique for mammoplasty in which free grafting of the nipples is performed. An elliptical transverse incision is made first, excising the entire lower pendulous portion of the breast including the areola. In this way, the normal contour of the breast can be restored.

From the excised portion of the breast, the areola and nipple are then dissected free as a full-thickness graft. After the original incision has been closed and the new contour of the breast is inspected, a small circular area of skin is removed from the proper place to apply the areola. The previously excised areola and nipple are then transplanted to this area as a graft and held in place by fine plastic suture material.

The end results of several of these cases were demonstrated, showing the excellent cosmetic effect obtained.

Harry D. Morris, New Orleans: **Amputations About the Foot and Ankle Following Trauma.**—This paper was based on 2,612 major amputations performed at an amputation center.

Amputations distal to the bases of the metatarsal bones are satisfactory because insertions of the leg muscles are preserved and the balance of the foot is maintained. However, often this amputation cannot be performed because adequate plantar flaps are not available. Such a transmetatarsal amputation necessitates a special prosthesis.

The Lisfranc, Chopart, Ricard, Boyd, and the Pirogoff amputation techniques through the posterior part of the foot have many disadvantages.

Morris devised a modification of the Chopart technique for posterior foot amputation. This technique was partially based on the report of **Vasconcelos**, in 1937.

Eight cases were operated on according to this technique. In four of these cases, reamputation was necessary. Morris felt certain that the other four patients would have done better with a Syme amputation or an ideal below-the-knee stump.

The Syme amputation offers the best solution to the problem of amputation of the foot proximal to the metatarsal base. Morris reviewed forty-two personal cases in which the Syme amputation had been performed. Subperiosteal resection of the calcaneus is preferred because there is less danger of injuring the blood supply of the flap. In only two of these cases was reamputation necessary.

One of the patients with reamputation had Buerger's disease. This was an error in clinical judgment and the patient should never have had a foot amputation. In the other patient, reamputation was necessary due to a defective plantar flap and not due to any fundamental shortcoming of the operative procedure itself.

Arnold S. Jackson, Madison: **Probacil, in the Treatment of Hyperthyroidism.**—All patients with hyperthyroidism observed by Jackson during the last year have been treated with propylthiouracil. A study of seventy patients so treated was reported. Thiouracil was discontinued entirely and supplanted by propylthiouracil, which appears to be more effective and far less dangerous. In only one case did the white blood cells count fall below 5,000, and there was no reaction observed in this instance.

At present, five children with exophthalmic goiter, all between the ages of 7 and 14, are receiving the drug. The basal metabolic rate has returned to normal in each instance. They have all gained an average of twelve pounds in weight and have been able to resume their schoolwork. When they have been on treatment twelve months, the drug will be discontinued with the hope that a cure will be effected. Jackson feels that propylthiouracil has been used for too short a time for anyone to say definitely that a cure may or may not be effected by its use in exophthalmic goiter.

It has been very advantageous in the preoperative preparation of complicated cases of multiple toxic adenoma. Patients with advanced cardiovascular disease, diabetes, and marked weight and strength loss have shown a remarkable response to treatment. With the use of this drug the heart condition is improved, the basal metabolism returns to normal, and thyroidectomy can be performed in one stage.

A compilation of cases from other physicians shows that approximately 1,500 patients with hyperthyroidism have now been treated with propylthiouracil. Only one case of agranulocytosis occurred, and that patient recovered.

Gayle Crutchfield, University, Va.: **Surgical Treatment of Hypertension.**—Crutchfield reported on 156 cases in which splanchnic nerve resections had been done for hypertension. He stated that in eighty-one of these cases the results were good and the patients have been able to return to some form of gainful occupation. The importance of careful selection of patients for this operative procedure was emphasized. Crutchfield stressed the fact that he did not believe the procedure adaptable to all patients who have an elevated arterial tension and he believes that the end results can be greatly improved if the patients are more carefully selected.

John A. Martin, Montgomery, Ala.: **Problem of Carcinoma of the Colon in the Southeast.**—This presentation was a statistical study of the occurrence of carcinoma of the colon in the southeastern states. There is no statistical evidence to indicate that any great progress has been made in the early recognition of carcinoma of the colon, in spite of recent educational campaigns.

The following are the reasons for the delay in the diagnosis and treatment of cancer of the colon: (1) failure on the patient's part to seek early medical aid; (2) failure of the physician to recognize early carcinoma; (3) physicians first consulted incapable of making early diagnosis or rendering the best service possible; (4) incorrect advice from physicians and delay in receiving adequate treatment after the diagnosis is made.

Martin emphasized the fact that if a similar system of physical and x-ray examinations now used in the diagnosis and treatment of tuberculosis were to be applied to cancer of the colon, the mortality of this disease would fall in a manner similar to that of tuberculosis.

One difficulty in curbing cancer in the southeastern United States is the fact that in only three states are records of cancer control kept. These are Louisiana, Georgia, and Mississippi.

William F. Rienhoff, Baltimore: **Carcinoma of the Lung, Diagnosis and Treatment.** Over a thirteen-year period, 327 cases of carcinoma of the lung were reported. These did not include the clinically inoperable cases. The high incidence in urban residents was pointed out. The disease is more frequent in males (6:1). The right and left lungs are involved approximately the same.

The age incidence did not vary from the usual incidence of other malignancies. Age seemed to offer no contraindication to operation.

Cough was the chief symptom in 71 per cent. Other symptoms were as follows: hemoptysis, 63 per cent; pain, 50 per cent; loss of weight, 39 per cent; hyperpnea, 23 per cent; pneumonitis, 18 per cent; fever, 13 per cent; and tightness in the chest, 3 per cent. The more common symptoms were discussed in detail. There are no pathognomonic signs or symptoms of primary carcinoma of the lung. This lesion may masquerade as any common pulmonary disorder.

In this series, the roentgenograms were positive in every instance. This is the most important method of examination. Second to roentgenograms in importance is bronchoscopy. In 70 per cent, biopsy findings were positive. A pulmonary new growth in the periphery or confined to the upper lobe bronchus may be beyond the vision of bronchoscopy. Bronchography can only reveal occlusion of the bronchus by a small growth which may not produce a shadow on the x-ray plate. Aspiration biopsy is often difficult to interpret, and not without danger.

Exploratory thoracotomy should be resorted to in doubtful cases.

In this series, the tumors occurred at or adjacent to the hilus in the majority of cases. A minority occurred in periphery. The method of spread was discussed. Those growths arising in the periphery are more often asymptomatic.

In 70 per cent of the 112 patients who had total pneumonectomy, metastasis to the bronchial and tracheal lymph nodes was found. In the 215 inoperable cases, in addition to regional lymph node involvement, the following organs were involved: supraclavicular and axillary lymph nodes, liver, pleura, pericardium and heart, contralateral lung, osseous tissue, brain and multiple areas in the skin and subcutaneous tissue.

Sixty-five per cent of the cases in this series were squamous-cell carcinomas and 34 per cent were adenocarcinomas.

Penicillin and sulfonamides are administered preoperatively. An important phase of preoperative treatment is the production of pneumothorax. The advantages of pneumothorax are: (1) it is a therapeutic test as to how the patient will tolerate removal of one lung; (2) the size of the lung is diminished, so that mechanical handling of the structure at operation is easier; (3) the patient has learned to breathe with one lung, and this avoids a certain degree of pleural shock; (4) the blood flow through the collapsed lung is less and, therefore, the strain on the right heart to shift a great blood flow through one pulmonary artery is graduated; (5) the location of the growth regarding the position relative to the mediastinum is often silhouetted and therefore located more accurately.

Total pneumonectomy is the only efficacious method of treatment of pulmonary carcinoma.

The details of operative technique were discussed. An anterior approach is preferred. Ligation of the pulmonary artery is the first step. Rienhoff closes the bronchial stump by the use of mattress sutures of interrupted silk or cotton placed through the bronchus in such a manner that the posterior membranous portion is approximated to the anterior cartilaginous wall, somewhat proximal to the end of the amputated stump, thus creating a viable area from 1 to 2 cm. distal to the suture line. A flap of parietal pleura should be sutured over the end of the stump of the bronchus.

At the end of the operation, 150,000 units of penicillin are introduced into the thoracic cavity. The trapped air is removed by leaving an aspirating catheter in the wound during closure. No postoperative drainage of the pleural cavity is necessary. If gross infection of the lung is present, 50,000 units of penicillin are introduced daily into the thoracic cavity, in addition to parenteral chemotherapy. No instances of empyema have been encountered.

In this series, from 1933 to 1939, there were 30 cases with 8 deaths (27 per cent). From 1940 through half of 1946, 82 patients were operated upon with 17 deaths (20.7 per cent). The total operative mortality was 22 per cent.

Marshall L. Michel, New Orleans: **Acute Malignant Obstruction of the Colon.**—A series of 55 cases was reviewed from Charity Hospital and Touro Infirmary, in New Orleans. The over-all mortality was 33 per cent. The cases were handled by twenty-five different surgeons. The maximum number of cases done by one surgeon was eight. The incidence of complete acute obstruction in all cases of carcinoma of the colon admitted was approximately 27 per cent.

The fact that the patient with malignant obstruction of the colon is in double jeopardy, first, from the obstruction and, second, from the malignant disease is important. The treatment of the obstruction is of primary importance, and the removal of the malignant growth should be postponed until a later date.

Acute obstruction of the colon often results in a closed loop obstruction. Perforation of the colon is a complication to be feared and occurred in eight of these fifty-five cases. Only two of these perforations occurred in the cecum.

In forty-one of the fifty-five cases, the obstruction occurred on the left side of the colon. The mortality rate was higher on the right side.

In a number of these cases, signs of acute obstruction were the first manifestation of the malignant disease. The importance of x-ray studies was emphasized. Both a flat plate of the abdomen and emergency barium enema should be performed in order to localize definitely the site of obstruction so that abdominal exploration can be cut down to a minimum.

Delay of surgical therapy of acute obstruction of the colon and attempts at conservative treatment greatly jeopardize the patient's chances of recovery. The Miller-Abbott tube is of no value in the treatment of obstruction of the large intestine.

In obstruction of the left colon, a simple loop colostomy of the right transverse colon is the procedure of choice, although cecostomy also gives good results.

In acute obstruction of the right side of the colon, the procedure of choice lies between cecostomy, ileotransverse colostomy, ileostomy or combination of ileostomy and ileotransverse colostomy.

E. Murphy Howard, Harlan, Ky.: **Obligations and Opportunities in Industrial Surgery.**—Howard pointed out that 90 per cent of industrial plants fall into the small plant category (500 workers or less). Accident frequencies run to 62 per cent higher than in large plants, yet they are unable to afford the medical and surgical staff which big industries employ as a matter of course.

Howard recommended that small plant medical cooperative be formed. Pay-roll deduction prepayments by the worker is the only solution in sight for this particular problem. Such plans are in effect in Pennsylvania, New York, Connecticut, and California.

The opportunities of industrial surgery were enumerated. The industrial surgeon must serve as internist, surgeon, orthopedist, toxicologist, radiologist and psychiatrist. Therefore, his previous training should be of a general nature, with particular emphasis on surgery and traumatology.

J. O. Rankin, Wheeling: **The Management of the Ununited Fracture.**—This presentation was based on 100 bone graft operations at a Naval hospital.

The following factors were responsible for the necessity of bone grafting procedures: (1) compound fractures in which proper and adequate débridement was not done; (2) compound fractures in which the patient was not seen in time by the surgeon to do a proper débridement; (3) relative frequency of compound comminuted fractures or fractures with

loss of bone surface from high velocity bullets or shrapnel; (4) incompletely reduced fractures or those in which there was interposition of soft tissue; (5) improper and ineffectual fixation after reduction; (6) improper use of external fixation pin units.

Careful preoperative care is important. Wounds connected with the fracture must be eliminated. Sequestra and foreign bodies should be removed. Soft tissue defects should be previously covered with skin grafts.

Since the advent of chemotherapy, the waiting period, from the time drainage ceases until the bone grafting, has been cut down from the usual six months to two years, to approximately eight weeks.

This waiting period can be adequately used by instituting physiotherapy, exercises, and massage. Casts or braces should not be kept on unless they maintain length. The patient's general condition should be investigated, and for twenty-four hours prior to operation, penicillin is administered.

Rankin prefers spinal anesthesia in the lower extremities, pentothal in the upper extremities, and endotracheal gas anesthesia for the mandible. During the operation, the patient should be supported with infusions and blood.

Rigid operating room technique is insisted upon. Fine cotton sutures are used.

The periosteum should be disturbed as little as possible. All scar tissue is removed from the end of the bone and the medullary cavity is widely opened. Screws retaining the grafts in position should be placed as far from the fracture site as possible and must traverse both cortices. A complete débridement is performed. The wound is dusted with sulfanilamide. All dead space is eliminated and the skin is closed with interrupted cotton sutures.

Many types of grafts were used in this series. Sliding inlay grafts were used principally in fractures of the humerus, femur, and tibia.

An attempt was always made to use at least one-third of the circumference of the shaft of the bone, so that there was a large, sturdy osseous bridge across the line of fracture.

Fractures of the clavicle with either nonunion or bony defects heal rapidly with the use of the split-rib technique.

Thoracic cage defects were repaired by subperiosteal removal of alternate ribs from the opposite side of the chest. One end of the transplant was sutured to the rib end with steel wire and the periosteum closed around it. The other end was wedged to a longitudinal split in the sternum and fixed with steel wire.

All patients were subsequently placed in padded plaster casts. Penicillin was given for a period of ten days. Sulfadiazine was sometimes added.

The distribution of grafts in this series was as follows: mandible, 6; clavicle, 4; humerus, 7; radius, 16; ulna, 13; radius and ulna combined, 9; scaphoid, 10; thoracic cage defects, 3; femur, 10; tibia, 18; internal malleolus, 4.

In four cases of the originally compound fractures, a small pocket of pus was encountered at the time of operation, even though there was no drainage. In all of these cases, the bone graft operation was performed and the wound was closed. Large doses of sulfadiazine were given and 100,000 units of penicillin were administered every three hours. One of the wounds healed by primary union. Two drained, but eventually healed with preservation of the graft and union of the fracture. In the fourth case, a graft of the radius was lost. At a later date, another graft was successfully applied to the radius.

Of the ten ununited scaphoid fractures, six healed with bony union. There were four in which there was no union, but apparently enough fibrous union occurred so that these men could return to limited duty status. There was only one case in which a fracture of the tibia occurred following removal of the bone graft, and this was approximately ten weeks following operation. All patients who had grafts removed from the tibia were immobilized in a cast or brace for two to three months.

J. A. Cunningham, Birmingham: **Hidradenomas of the Vulva, Report of Five Cases.**—The possible relationship between hidradenoma and carcinoma of the breast was discussed.

The microscopic and gross pathology of five cases was demonstrated by means of lantern slides.

Many of these growths simulated intraductal papilloma of the breast.

Cunningham reported four cases, in which carcinoma of the vulva originated in hidradenoma. The relationship of hidradenoma of the vulva to carcinoma is important, and the possibility of malignancy should be kept in mind in all such cases.

J. R. Young and **Claude W. Perry**, Anderson: **An Institutional Study of Acute Appendicitis Over a Twenty-Three-Year Period.**—Acute appendicitis, 5,624 cases, were analyzed. This represents a twenty-three-year period, from 1923 through 1945. During this period, there was a progressive decrease in the mortality. This was partially due to more intelligent cooperation from the layman. In the first decade, 24 per cent of all appendices were ruptured when the patient was admitted. During the last six years, only 5.3 per cent were found to be ruptured.

Further credit for the decrease in mortality goes to the family doctor for more prompt diagnosis, to improved surgical treatment, and to the introduction of new measures, particularly chemotherapy.

The McBurney incision was used in all cases in this series, and Young and Perry feel strongly concerning its advantages. A technique was also recommended for marsupializing the peritoneum in order to wall off the abdominal wall and prevent wound infection.

During the past five years, the sulfonamides have been used intraperitoneally in all ruptured cases. Young and Perry are of the opinion that such a procedure is helpful, although they have no definite evidence to prove this.

Other important phases in the treatment of acute appendicitis are as follows: (1) withholding of nourishment by mouth after operation; (2) maintaining the fluid balance by infusion; (3) oxygen inhalation in distended cases; (4) use of plasma and blood transfusions when indicated; (5) maintaining decompression by the Wangensteen or Miller-Abbott tube; (6) vitamin therapy; (7) prompt surgical drainage of residual abscesses; (8) the use of sulfonamides and penicillin as indicated.

The most marked improvement in mortality occurred in the patients with no rupture. Between the period of 1923 and 1932, the mortality was 1.8 per cent in these cases and between 1940 and 1945, the mortality percentage was .36 per cent. The mortality in ruptured appendicitis in this series did not diminish markedly. The mortality percentage in the period between 1923 and 1932 was 13 per cent, whereas in the period between 1940 and 1945, the mortality in ruptured appendicitis had dropped to only 11.2 per cent.

Francis M. Woods and **Richard H. Overholt**, Brookline: **Segmental Pulmonary Resection in Bronchiectasis.**—The bronchopulmonary segment is a surgical unit and lends itself to removal without undue technical risks. Segmental resection is now being used in bronchiectasis. Two fundamental principles of surgery are accomplished: (1) cure of the patient and (2) the preservation of as much functional tissue as possible.

Bronchiectasis is a primarily segmental disease, and is frequently bilateral. It usually involves certain bronchopulmonary segments within the lobe, rather than involving the entire lobe. In 100 cases of bronchiectasis, 80 per cent involved multiple segments, and in 30 per cent the disease was bilateral. In this series, the lower division of the left upper lobe (lingula) was involved in 60 per cent of those patients whose principal disease was in the left basal segment. The middle lobe was found to be involved with the right basal segment in 45 per cent of cases. A common bilateral pattern shows involvement of the right middle, the lower division of the left upper (lingula), and both right and left basal segments.

If entire lobes are considered as surgical units, serious respiratory embarrassment may result if the disease is bilateral.

Accurate delineation of the bronchopulmonary segment is accomplished by: (1) deflation of the lobe, (2) temporary occlusion of the bronchus, (3) reinflation of the lobe by means of increased positive intratracheal pressure. The anatomic details of each broncho-

pulmonary structure were then enumerated, with particular emphasis on the location of the various bronchi and blood vessels.

The objections to the clamp and suture method are: (1) it is impossible to place the clamps precisely in the intersegmental plane, (2) the application of clamps across the lung tissue is crude and traumatizing, (3) excessive suture material is necessary, predisposing the patient to secondary infection and foreign body reaction, (4) puckering and reduction in the size of the remaining segments is produced.

Pulmonary segmental resection according to the technique of Woods and Overholt was discussed in detail. All of the hilar structures of each segment are identified and divided prior to dissection of the intersegmental plane. These structures are the bronchus, the pulmonary artery, veins, and visceral pleura. Then the dissection is carried along the intersegmental plane through which the bronchi do not traverse and, for practical purposes, which plane is avascular. Prompt healing of the denuded lung surface follows and air leakage is of negligible importance.

Woods and Overholt have adopted the face-down position with the diseased side dependent for pulmonary resection. They reported twenty-three segmental resections performed on twenty-one patients for primary bronchiectasis. No deaths have occurred. Bilateral lesions were present in eleven cases.

The incidence of complications is somewhat higher than those following lobectomy. A reduction of complications will probably follow wider use of this procedure. The preservation of pulmonary tissue is important.

Milton A. Gilmore, Parkersburg, W. Va.: **The Control of Hemorrhage in Otolaryngology.**—Hemorrhage from the ear is usually of a minor nature. Occasionally, however, as the result of extensive skull fractures in this region, hemorrhage from the ear may be severe. The treatment of choice is packing. Occasionally, marked hemorrhage may occur from the lateral sinus during mastoidectomy. Here again, tight packing is the treatment of choice. The use of the newly developed hemostatic agents in conjunction with the pack is also a worth-while procedure.

Hemorrhage from the nose is the most common type dealt with in otolaryngology. These cases may be divided into two main groups: (1) local and (2) systemic. In handling of an acute massive nasal hemorrhage, suction should be used to clear out the blood and definitely determine the bleeding point. Occasionally, cauterization of the bleeding point may stop the hemorrhage. However, in many cases, packing is necessary. Packing with moist packs soaked in adrenalin solution is still an efficacious method, and the use of a local anesthetic is often indicated. Recently, the use of cotton tampons immersed in thromboplastin solution has proved to be superior to any type of nasal pack.

It is necessary to pack the posterior part of the nares on rare occasions. When this is done, the pack should always be removed in a period of forty-eight hours. Fracture into the posterior part of the nares may be extremely severe following basal skull fracture. In the most severe forms of nasal hemorrhage, ligation of the external common carotid may be necessary. Gilmore then discussed in detail the various arteries which supply different parts of the nose and mentioned in detail his own technique for ligation of the ethmoidal arteries by a transorbital approach.

Nasopharyngeal hemorrhage occasionally presents a problem to the otolaryngologist. Hemorrhage here may be the result of tumor, but most often is post-tonsillectomy. The most serious type of nasopharyngeal hemorrhage is that which occurs in conjunction with infection. Usually it is impossible to stop this type of hemorrhage, and ligation of the common carotid is frequently necessary.

Post-tonsillectomy hemorrhage is of two types: (1) primary and (2) secondary. The primary type of hemorrhage occurs immediately following tonsillectomy. Novocain anesthesia should be used and each bleeding point should be carefully isolated, clamped, and ligated. Gilmore strongly opposes sewing the tonsil pillars together in order to bring about

control of the hemorrhage. He is also of the opinion that local applications are of little or no use.

Secondary post-tonsillectomy hemorrhage is usually not as massive but is often difficult to control because of the secondary infection. He is of the opinion that the use of lozenges which contain the sulfa drugs or penicillin is worth while in post-tonsillectomy cases in order to prevent secondary infection.

Hemorrhage from esophageal varices is a difficult problem. Electrocoagulation and injections of sodium morrhuate have been advocated, but have been used with very little success.

Hemorrhage from carcinoma of the esophagus is difficult to control. Electrocoagulation and implantation of radon seeds are occasionally of value. Foreign bodies of the esophagus, peptic ulcers, or tuberculous ulceration may ulcerate through the walls of the esophagus and erode blood vessels, causing massive hemorrhage.

Hemorrhage from the tracheobronchial tree is extremely common. There are many different causes. Gilmore did not go into detail of the various causes of such hemorrhage, but mentioned several of the most common. Hemangioma of the bronchial tree is somewhat more common than generally believed and often such hemorrhage can be controlled by simple coagulation through the bronchoscope.

Joseph St. Stewart, Miami: **Extrinsic Duodenal Obstruction in the Newborn.**—Stewart reviewed from the literature forty-two such cases occurring in children under 5 years of age. Of these cases, 40 per cent were undiagnosed. He stressed the recent work of **Ladd** and **Gross,** who have shown how embryologic anomalies result in pressure on the duodenum, producing obstruction. The embryology of intestinal rotation was then discussed. The various anomalies were demonstrated by slides showing how it is possible for such anomalies to produce extrinsic pressure on the duodenum.

Stewart then reported two cases of obstruction of the second part of the duodenum due to the hepatic flexure of the colon lying over the duodenum in an incompletely rotated colon.

In one of these cases, the diagnosis was made correctly and operation produced immediate relief. In the second case, the patient had had a previous laparotomy and appendectomy with no relief. Subsequent operation revealed the true nature of the obstruction and cause of abdominal symptoms. Mobilization of the right half of the transverse colon and relief of pressure on the duodenum produced complete relief of symptoms.

D. P. Hall, Louisville: **Biliary Peritonitis.**—There are four causes of bile peritonitis: (1) gall bladder disease, (2) defect or perforations of the bile duct, (3) trauma, and (4) congenital defects. Hall then demonstrated how each of these conditions could produce bile peritonitis and also discussed the signs and symptoms of bile peritonitis.

The possibility of bile peritonitis occurring in cases in which actual perforation of the gall bladder or ducts is not present must be kept in mind. If obstruction of the common bile duct and cystic duct is present, the back pressure in the gall bladder may be such as to cause a so-called ''sweating'' gall bladder. The result is extravasation of bile through the wall of the gall bladder into the peritoneal cavity, producing a bile peritonitis without actual perforation in the biliary tree.

Duncan McEwan, Orlando: **Mistaken Surgical Diagnoses in Hookworm Disease.**—McEwan analyzed a series of fifty-six patients admitted to his surgical service with abdominal pain. In 50 per cent of these cases, hookworms were found to be present in the stool, and specific therapy brought about complete relief of the abdominal symptoms. McEwan then discussed in detail the life cycle of the hookworm and stressed particularly the difference between the Asiatic hookworm and the species found in North America. Details of the pathology of hookworm enteritis were demonstrated, and it was emphasized how these patients may complain of abdominal pain. The presence of the enteric lesions in the ileocecal region may produce pain in the lower right quadrant, simulating appendicitis.

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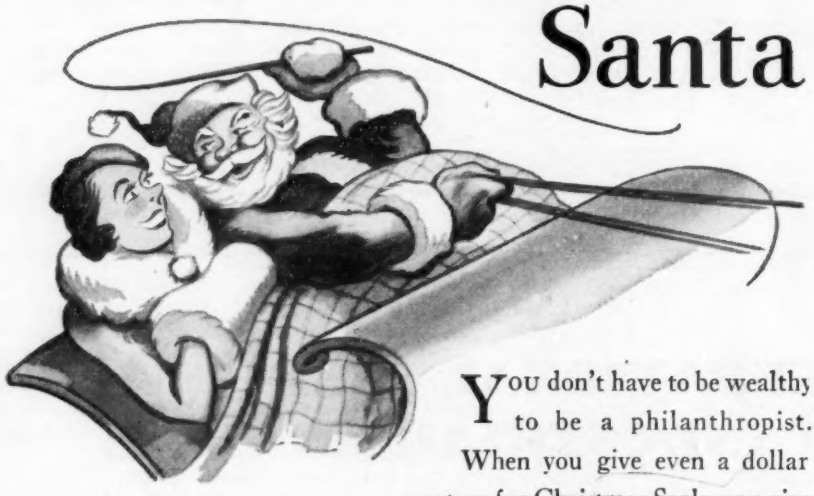

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